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THE VAPOR PRESSURES OF LIQUID MIXTURES AND FRACTIONAL DISTILLATION.

BY

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THE partial and total vapor pressures of mixtures figure in two important chapters of physical chemistry, *viz.*, the theory of solutions and the theory of fractional distillation. The work described in this communication was carried out mainly in view of the needs of the theory of distillation.

Partial pressures cannot be directly measured as such. They are calculated from the molecular composition of a given vapor on the assumption that the pressures are proportional to the relative numbers of molecules. Hence, all methods of "measuring partial pressures" really consist in determining the composition of vapors in equilibrium with liquid mixtures.

The principal method employed in the past[1] consisted in distilling off a small amount from a large quantity of a given mixture and determining the composition of the distillate. The assumption involved, *viz.*, that the composition of the vapor does not vary during the distillation, can be strictly true only

[1] See especially Zawidzki, *Z. physik. Chem.*, 35, 129 (1901).

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if the amount of distillate is infinitely small by comparison with the mother liquid. In practice one cubic centimetre is distilled off from about 100 cc. In some cases the removal of such a fraction is accompanied by appreciable changes in the vapor composition during distillation; but a graver source of inaccuracy lies in the difficulty of handling one cubic centimetre of a volatile organic mixture for analysis. Also, moisture is likely to accumulate in the first small fraction distilled off.

§1. *A Precise Method of Determining Partial Pressures.*

The writer, with collaborators, succeeded in devising a method which is apparently free from the errors and uncertainties attached to the older methods. The principle of the new method was first stated in a paper published jointly with A. B. Lamb and F. E. Breithut,[2] from which I quote: "If a binary liquid whose components are in the ratio $x/(1-x)$ is in equilibrium with a vapor containing the same components in the ratio p_1/p_2, then a saturated vapor of this composition will bubble through the liquid without producing, or itself undergoing, any change. If, on the other hand, a saturated vapor of any other composition, say p'_1/p'_2, is passed through the same liquid, the composition of the liquid will gradually change until the ratio of its components has become $x'/(1-x')$ corresponding to the composition p'_1/p'_2 of the vapor. After that the vapor may be passed through the liquid indefinitely without affecting its composition. Further, since condensation or evaporation involves a transfer of heat, and hence a rise or fall in temperature, it follows that if a saturated vapor of definite composition at the temperature T' be passed through a liquid mixture of the same components, the temperature T of the liquid will gradually approach T' as equilibrium is attained.

"In brief, then, if a mixed vapor of constant composition is passed through a liquid mixture of the same components, the composition and temperature of the liquid will steadily change until complete equilibrium, as regards both temperature and pressure, has been established. A stationary temperature will demonstrate the attainment of equilibrium. The vapor bubbling

[2] *Journal of the American Chemical Society*, 31, 448 (1909).

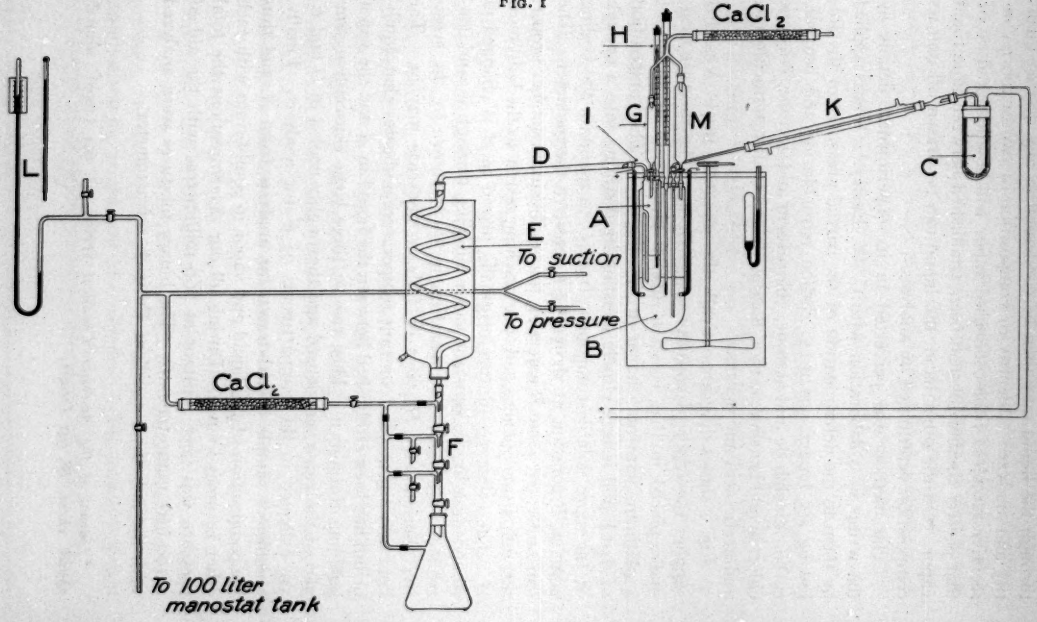
through the liquid may then be condensed in any desired quantity and analyzed. Identity of composition of two or more consecutive samples of the condensed vapor will be additional proof that perfect equilibrium had been established between liquid and vapor. On the other hand, the liquid can be drawn off and its composition determined by analysis."

The method was perfected in its experimental details by the writer in collaboration with C. W. Easley.[8] It was applied by them to the determination of the partial pressures of the following six binary mixtures: carbon tetrachloride and benzene, carbon disulphide and acetone, chloroform and acetone, ethylene chloride and benzene, carbon disulphide and carbon tetrachloride, and acetic acid and benzene.

Fig. 1 shows diagrammatically the apparatus used. Vessel *B* supplies the vapor of constant composition. The mixture originally placed in that vessel is heated electrically by means of a platinum wire not shown in the diagram. The composition of that liquid is kept closely constant by distilling into it enough of the more volatile component from *C* to maintain the boiling point in *B* constant as shown by a sensitive thermometer. The constant vapor from *B* enters *A*, the equilibrium chamber proper, through a side opening and tube reaching nearly to the bottom of *A*. The arbitrary mixture originally placed in *A* is changed in composition by the constant vapor bubbling through it, and consequently the boiling temperature in *A*, as shown by the sensitive thermometer *H*, rises or falls, as the case may be. The final attainment of a constant temperature indicates that equilibrium has been established between the liquid in *A* and the vapor bubbling through it. Then two or three large consecutive samples of the vapor, condensed and thoroughly cooled in *D* and *E*, are collected in the compartments of *F* for analysis. Finally, a sufficient sample is withdrawn for analysis from *A*, and thus the composition of the liquid and vapor in equilibrium with each other becomes known. During all our determinations the total pressure was kept constant at 760 millimetres with the aid of a 100-litre manostat tank. The binary mixtures were analyzed with the aid of an excellent Pulfrich refractometer.

[8] *Journal of the American Chemical Society*, 31, 953 (1909); also *Z. physik. chem.*, 68, 641 (1910).

FIG. 1


CaCl2
H
I
G
M
K
L
D
C
A
E
To suction
To pressure
B
CaCl2
F
To 100 liter
manostat tank

The theoretical treatment of the results was founded on Kirchhoff's equation, which correlates the relative temperature gradient of partial pressures with the heat of dilution.[4] If the composition of mixtures is expressed, as done by Gibbs, in terms of molar fractions (molecular percentages divided by 100), the Kirchhoff equation assumes the form

$$\frac{\partial}{\partial T}\log\frac{P_1}{p_1} = \frac{1}{RT^2}\cdot Q - \frac{1-x}{RT^2}\cdot\frac{\partial Q}{\partial x},$$

where x is the molar fraction in the liquid phase of the component whose partial pressure in the vapor is p_1 and whose vapor pressure in the isolated state is P_1. The heat evolved in mixing the molar fractions x and $1-x$ of the two components is denoted by Q, and the absolute temperature by T.[5]

The right-hand member of the equation has RT^2 in the denominator. R, the gas constant, amounts in heat measure to nearly 2 (calories). And if the centigrade temperature is about 43°, the numerical value of T is 316, that of T^2 is about 100,000, and that of RT^2 is about 200,000. The relative change of $\frac{P_1}{p_1}$ with the temperature is consequently one 200,000th part of the heat of dilution. *And if the latter is moderate, as it is in the case of most organic mixtures, the change of* $\frac{P_1}{p_1}$ *with the temperature is negligibly small.*

The partial pressure of a mixture and its molar composition have been correlated by a semi-theoretical function introduced by Margules.[6] For the two components:

$$p_1 = P_1 x e^{\frac{\alpha_2}{2}(1-x)^2 + \frac{\alpha_3}{3}(1-x)^3 + \frac{\alpha_4}{4}(1-x)^4}$$

and

$$p_2 = P_2(1-x)\,e^{\frac{\beta_2}{2}x^2 + \frac{\beta_3}{3}x^3 + \frac{\beta_4}{4}x^4}$$

---

[4] *Poggendorff's Annalen*, 103, 200, and 104, 615 (1858).

[5] The above equation was given in our original communication in an imperfect form; but the conclusions there drawn are not affected by the correction.

[6] *Sitzungsbericht der Wiener Akademie*, 104, 1243 (1895).

Since, according to the Kirchhoff equation, the ratio $\frac{p}{P}$ is practically independent of the temperature, the coefficients a_2, a_3, a_4, β_2, β_3, and β_4 must likewise remain constant within moderate temperature ranges.

The pair of Margules functions must satisfy the well-known differential equation first deduced by Duhem,[7] and later rediscovered by Margules himself[8]:

$$d \log p_1 / d \log p_2 = d \log x / d \log (1-x).$$

This permits of eliminating one of the two sets of coefficients in the Margules functions, and then the functions may be readily combined into the following equation:

$$\log \frac{p_1(1-x)}{p_2 x} = \log \frac{P_1}{P_2} + a_2\left[(1-x) - \frac{1}{2}\right]$$

$$+ \frac{a_3}{2}\left[(1-x)^2 - \frac{1}{3}\right] + \frac{a_4}{3}\left[(1-x)^3 - \frac{1}{4}\right].$$

Since the a's are independent of temperature variations, this last equation will represent partial pressures measured either isothermally or isopiestically. Our own measurements, as before stated, were isopiestic.

The principle of the practical constancy of $\frac{P}{p}$ during moderate temperature changes is capable of a variety of useful applications. I should like to point out here one such application not mentioned in the original communication. Professor Morse and his collaborators, at Johns Hopkins University, have carried out a large number of direct determinations of osmotic pressure. One of the questions submitted by them to the test of experiment was whether osmotic pressure, like gas pressure, is proportional to the absolute temperature, and at one time experiment seemed to indicate that it was not. Now, osmotic pressure must obey the following thermodynamic equation:

$$\pi = \frac{1000\,RST}{M_0} \log \frac{P}{p}.$$

[7] *Ann. de l'Ecole normale sup.* (3), 4, 9 (1887).
[8] *Sitzungsbericht der Wiener Akademie*, 104, II, 1243 (1895).

Here R is the gas constant, S is the density of the solution in which the osmotic pressure is π, M_0 is the molecular weight of the solvent in the gaseous state, and P and p are the vapor pressures of the solvent in the isolated state and in the solution, respectively. Dr. Morse has experimented mainly with solutions of cane sugar and within temperature ranges of only about 25 degrees. When sugar is dissolved in water the heat-change is so slight that in common experience one does not realize that there is any temperature change at all. Therefore, within Dr. Morse's temperature range, according to the principle explained above, the ratio $\frac{P}{p}$ ought to remain all but perfectly constant. Further, within ranges of 25 degrees the density of a sugar solution scarcely varies. The osmotic pressure equation therefore assumes the form

$$\pi = T \times \text{constant.}$$

In other words, the principle of the constancy of $\frac{P}{p}$ teaches that according to thermodynamics the osmotic pressure of a sugar solution *must* be very closely proportional to the absolute temperature. As a matter of fact, the most recent measurements at Johns Hopkins show that osmotic pressure obeys this temperature law within the slight experimental errors.

Returning to our partial pressure measurements, I will reproduce here, by way of an example, the results obtained in the case of carbon tetrachloride and benzene. In Table I the first column gives the observed boiling points; the second column gives the composition of the boiling mixtures in vessel A. The third and sixth columns (under p_1 and p_2 obs.) give the observed composition of the vapor expressed in terms of partial pressures, the sum being, as stated, 760 millimetres throughout. The fourth and seventh columns (under p_1 and p_2 calc.) give the corresponding partial pressures calculated by the equation:

$$\log \frac{p_1(1-x)}{p_2 x} = 0.097291 + 0.22284\left[(1-x) - \frac{1}{2}\right]$$

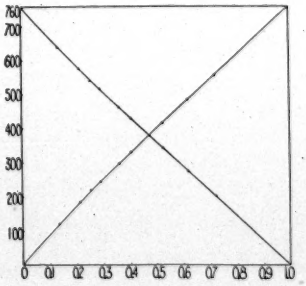
$$- 0.15975\left[(1-x)^2 - \frac{1}{3}\right] + 0.14883\left[(1-x)^3 - \frac{1}{4}\right].$$

Finally, the fifth and eighth columns give the percentage differences between the calculated and the observed values of p_1 and p_2, respectively. The agreement between calculation and experiment is all that can be desired. Fig. 2 reproduces the same set of results graphically.

TABLE I.

1 B. p. obs.	2 x CCl_4 in liquid	3 p_1 obs.	4 p_1 calc.	5 Diff. per cent.	6 p_2 obs.	7 p_2 calc.	8 Diff. per cent.
80.23°	0	0	0	0	760.0	760.0	0
79.36	0.1364	120.2	120.0	—0.03	639.8	640.0	+0.03
78.82	0.2157	183.9	184.1	+0.03	576.1	575.9	—0.03
78.62	0.2573	218.7	216.6	—0.28	541.3	543.4	+0.28
78.48	0.2944	244.1	245.1	+0.14	515.9	514.9	—0.14
78.15	0.3634	297.7	297.1	—0.08	462.3	462.9	+0.08
77.97	0.4057	330.6	328.5	—0.28	429.4	431.5	+0.28
77.57	0.5269	416.8	416.9	+0.01	343.2	343.1	—0.01
77.23	0.6202	485.0	484.1	—0.12	275.0	275.9	+0.12
77.07	0.7223	556.9	557.2	+0.04	203.1	202.8	—0.04
76.69	1.0000	760.0	760.0	0	0	0	0

FIG. 2.



§2. *A Rapid Laboratory Method of Measuring Partial Pressures.*

The method described in §1, while precise and undoubtedly reliable, is also laborious and requires some manipulative skill. In connection with distillation experiments, in the scientific as well as in the industrial laboratory, it left a need for a simpler and more rapid laboratory method.

Such a method has recently been devised by C. W. Bacon and R. H. White in collaboration with the writer. It will be briefly described here for the first time, a detailed description and an exhaustive statement of results to be published before long.

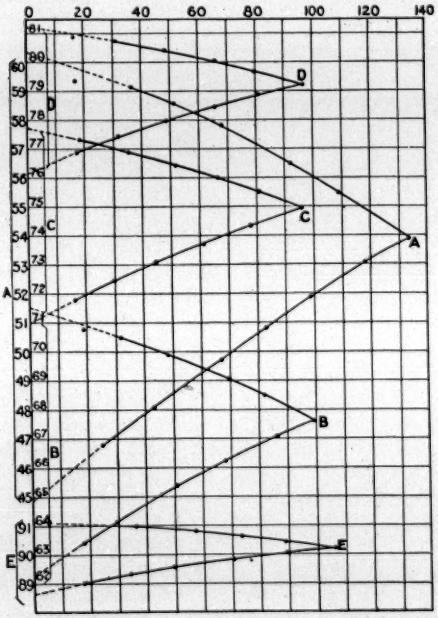
Imagine, first, that from half a dozen samples of equal weight and identical composition we should distill off, say, respectively, 1, 2, 3, 4, 5 and 6 grammes, avoiding all reflux condensation, and analyze the six distillates. Then by plotting the results with the respective weights as abscissæ, and the corresponding compositions as ordinates, and extending the curve so obtained to the composition axis, we should obtain *the composition of the first infinitely small amount of distillate given off by the mixture,* in other words, the composition of the vapor in equilibrium with that mixture. In reality we do not take six separate samples, but a single sample of moderate weight, and distill off half a dozen consecutive quantities, several grammes each. A simple arithmetical computation gives us the results that *would* be obtained in the imaginary experiment just outlined. As to the reliability of the exterpolation, experience has shown that the curves obtained are exceedingly smooth and that the graphic exterpolation involved is attended with no doubt whatever. Fig. 3 reproduces the curves obtained in the case of carbon disulphide and carbon tetrachloride.

A second phase of the same method is as follows: Knowing the weights and compositions of our actual distillates Nos. 6 and 5, it is easy to calculate the weight and composition that *would* be obtained by mixing 6 and 5 together. Similarly, it is easy to find the weight and composition that would result from mixing 6, 5, and 4, then 6, 5, 4, and 3, etc. We now make the weight of 6 an abscissa and its composition an ordinate, the combined weight of 6 and 5 another abscissa and their combined composition another ordinate, etc. The upper ends of the ordinates lie on a new curve, which we again extend until it meets the composition axis. The curve represents the course of what may be called *a reversed distillation,* and the point in which it meets the composition axis gives the first infinitely small amount of vapor that would return to the given mixture (that is, to the residue from the distillation involved in the first phase of the method). In other words, if we determine the composition of the residue by analysis, the point in question on the curve shows

what vapor can exist in equilibrium with that residue (see Fig. 3).

In this manner, driving off half a dozen consecutive samples yields two points of the required vapor-composition curve. Such a distillation takes about ten to twelve minutes.

FIG. 3.



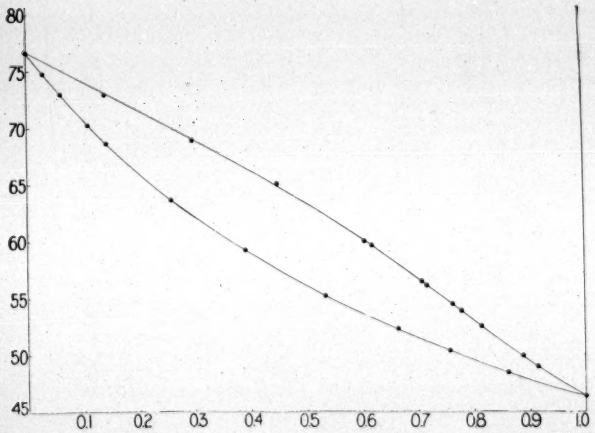
If any time is consumed, it is rather in determining the indices of refraction of the six distillates for the purpose of analysis, each determination taking about five minutes. The method is, therefore, extremely rapid. On the other hand, the simplicity of manipulation is such that an undergraduate student could be trained in a few days to make determinations of considerable precision. *But the greatest advantage of the method will often*

consist in the possibility of using it with small quantities of substance.

It would be easy to show that by collecting a larger number of distillates it is possible to obtain at once a larger number of points on the vapor composition curve. But I will not insist.

Fig. 4 reproduces the results yielded by the method in the case of carbon disulphide and carbon tetrachloride. The lower curve represents the boiling points of the various possible mixtures. The upper curve represents the composition of the

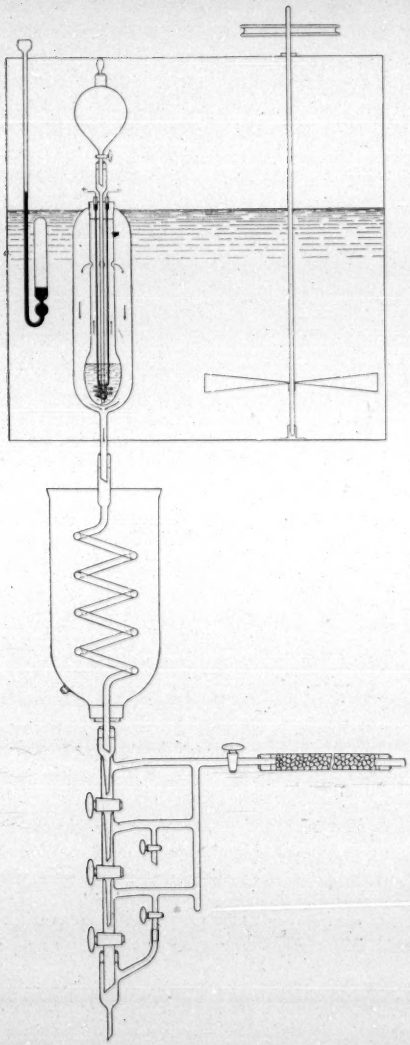
FIG. 4.



vapors in equilibrium with the liquid mixtures. Any two points of the two curves lying on the same horizontal line have for their abscissæ, respectively, the composition of a liquid and its vapor, counted in molar fractions of carbon disulphide from left to right.

The apparatus devised for carrying out these distillations without reflux condensation is shown by Fig. 5. A pear-shaped vessel similar to a Kjeldahl flask, surrounded by a glass jacket fused on to it, contains the liquid to be distilled. Heat is supplied electrically by a platinum wire. The cork closing the flask carries, besides the heater, a funnel through which the liquid

FIG. 5.



is introduced. The vapor escapes through four circular holes in the neck of the flask downward through the jacket into a condensing coil surrounded by a freezing mixture, and from there into the several compartments of the receiving vessel. The vapor itself, surrounding the inner boiling vessel, prevents condensation within it. To further insure this effect, the distillation apparatus is in a thermostat whose temperature is several degrees higher than that of the boiling liquid.

§3. *A New Relationship between the Total and Partial Pressures of Binary Mixtures.*

A study of the extant data on the partial pressures of binary mixtures, combined with Konovaloffs' semi-quantitative principles relating to the shape of the total pressure curve, has guided us to the construction of an expression which correlates the total and partial pressures and permits of *calculating the latter from the former.*[9]

Konovaloff's principles indicate that the steeper the total pressure curve, the more different is the composition of the vapor from that of the liquid. The composition of the vapor is expressed by the ratio p_1/p_2, the composition of the liquid by $x/(1-x)$, and the relation between liquid and vapor by the quantity,

$$\frac{p_1(1-x)}{p_2 x}.$$

When the total pressure curve passes through a maximum or minimum

$$\frac{d\pi}{dx} = 0,$$

where π denotes the total pressure. At the same time vapor and liquid are identical in composition, and hence

$$\frac{p_1(1-x)}{p_2 x} = 1.$$

This points to the differential coefficient of π with respect to x being a logarithmic function of the relation between vapor and

[9] A more detailed account of this relationship will shortly be published in a joint paper with C. W. Bacon.

liquid. Assuming it to be simply proportional to the logarithm, we have

$$\frac{d\pi}{dx} = k \log \frac{p_1(1-x)}{p_2 x}.$$

Further, in case the total and partial pressure curves are all straight lines (G. N. Lewis's "ideal solutions"), then

$$\frac{d\pi}{dx} = P_1 - P_2$$

and

$$\frac{p_1(1-x)}{p_2 x} = \frac{P_1}{P_2}.$$

In order that the above relationship should include this case also, it is necessary that

$$k = \frac{P_1 - P_2}{\log P_1 - \log P_2}.$$

We thus have in general:

$$\frac{d\pi}{dx} = \frac{P_1 - P_2}{\log P_1 - \log P_2} \log \frac{p_1(1-x)}{p_2 x}.$$

We have tested out this semi-theoretical equation in a number of typical cases and have found it to yield results of great precision. The method of procedure is as follows.

The isothermal total pressure curve is expressed in the form of a parabolic function of the fourth degree in x. This gives the value of the constant

$$\frac{P_1 - P_2}{\log P_1 - \log P_2}.$$

Differentiating, and dividing the differential coefficient by the constant, we get an expression of the third degree in x, which is equated to

$$\log \frac{p_1(1-x)}{p_2 x},$$

Knowing the total pressure p_1+p_2, it is then easy to find the values of the partial pressures.

By way of an example, I will reproduce the results obtained in the case of carbon tetrachloride and benzene. The total and partial pressures of this system have been measured by Zawidzki

(loc. cit.) at 50°. Zawidzki's total pressure curve was expressed, with the aid of the method of least squares, by the equation

$$\pi = 268.075 + 80.853x - 43.826x^2 + 16.531x^3 - 13.695x^4.$$

In Table II[10] the first column gives the molar fractions of the several liquids studied by Zawidzki; the second column gives the experimental values of the total pressures; the next column gives the calculated values of the total pressures, showing how well the above equation reproduces the experimental results; the fourth column gives the experimental values of the partial pressures of carbon tetrachloride; the fifth column gives the same partial pressures calculated from the total pressures by the method just outlined; finally, the sixth column gives the percentage differences between calculation and experiment. These differences amount for the most part to only 0.1 to 0.2 per cent.

TABLE II.

x	π obs.	π calc.	p_1 obs.	p_1 calc.	Diff. per cent.
0.0507	271.8	272.1	18.5	17.8	—0.25
0.1170	277.6	277.0	40.5	40.2	—0.11
0.1758	281.5	281.0	59.7	59.6	—0.03
0.2515	285.4	285.8	82.9	83.9	+0.35
0.2947	288.3	288.4	97.0	97.5	+0.17
0.3953	294.5	293.9	128.7	128.7	0.00
0.5587	301.0	301.1	176.4	177.9	+0.17
0.6755	305.2	304.9	211.8	212.9	+0.13
0.7652	306.8	307.0	238.5	238.4	—0.03

§4. *A Theory of Fractional Distillation Based on the Relationship Developed in* §3.

The principal question to which a quantitative theory of distillation must give answer may be formulated in simple terms as follows: Given a mixture containing $100x_0$ molar per cent. of one of the components; what per cent. by weight of the whole must be distilled off in order to change the composition from $100x_0$ to $100x$?

Konovaloff's theory of fractional distillation, given in all text-books of physical chemistry, while rigorously correct, is also purely qualitative and incapable of solving such a problem.

[10] Computed by C. W. Bacon.

A quantitative theory, proposed some years ago by Barrell, Thomas, and Young,[11] and which may be found in the later editions of Nernst and other text-books, is based on a formula introduced by Brown.[12] According to this, the ratio of the weights of the two components in the vapor is at every instant proportional to their ratio in the liquid:

$$\frac{d\xi}{d\eta} = c\frac{\xi}{\eta},$$

or

$$\frac{d \log \xi}{d \log \eta} = c.$$

That Brown's formula cannot be generally true, may be seen as follows: At a maximum or minimum of the total pressure curve,

$$\frac{d\xi}{d\eta} = \frac{\xi}{\eta}$$

and hence, in general, according to Brown's formula,

$$c = 1.$$

But this would mean that liquid and vapor are identical for *all* compositions, which is obviously untrue. In view of this it is not surprising that experiments failed, in most cases, to agree with the theory based on Brown's formula.

A truer answer to the above question has been given by Lord Rayleigh.[13] But Lord Rayleigh's formulation requires a knowledge of the partial pressures in each special case.

The relationship developed in the previous section permits of answering our question and of foretelling the course of a fractional distillation apparently with precision, on the basis of nothing but a knowledge of the total pressure curve at some constant temperature not too far removed from those observed during the distillation (since, again, the constants a_2, a_3, and a_4 remain unchanged within moderate temperature ranges). It may be added that the determination of an isothermal total pressure curve is scarcely more difficult than the determination of an ordinary boiling-point curve.

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[11] *Phil. Mag.* (5), 37, 8 (1894).

[12] See Young, "Fractional Distillation" (London, 1903), p. 93.

[13] *Phil. Mag.* (6), 4, 521 (1902).

Let ξ and η represent respectively the absolute *weights* of the two components in the liquid, and $d\xi$ and $d\eta$ their absolute *weights* in the vapor. Then

$$\frac{d \log \xi}{d \log \eta} = \frac{p_1 (1 - x)}{p_2 x}.$$

Further, if we write, for the sake of brevity,

$$\frac{P_1 - P_2}{\log P_1 - \log P_2} = \frac{1}{S},$$

the equation of §3 assumes the form

$$\frac{d \log \xi}{d \log \eta} = e^{\frac{S d\pi}{dx}}.$$

It is easy to see, further, that

$$d \log \eta = d \log \xi = \frac{dx}{(1 - x)}$$

Therefore,

$$d \log \xi = \frac{e^{\frac{S d\pi}{dx}}}{\left(e^{\frac{S d\pi}{dx}} - 1\right)(1 - x)\, x} \cdot dx,$$

and if ξ_0 is the original weight of the first component,

$$\log \frac{\xi}{\xi_0} = \int_{x_0}^{x} \frac{e^{\frac{S d\pi}{dx}}}{\left(e^{\frac{S d\pi}{dx}} - 1\right)(1 - x)\, x} \cdot dx.$$

Similarly,

$$\log \frac{\eta}{\eta_0} = \int_{x_0}^{x} \frac{dx}{\left(e^{\frac{S d\pi}{dx}} - 1\right)(1 - x)\, x}.$$

These equations have been tested experimentally by C. W. Bacon in collaboration with the writer, and the agreement between theory and experiment was nearly perfect. For example,

working with ethyl iodide and ethyl acetate: in order to produce a given change of composition, in one case, theory required that 37.42 per cent. must be distilled off. The change was actually produced by distilling off 37.44 per cent.

If the total and partial pressure curves are straight lines, the equations are much simplified. We get

$$\frac{\xi}{\xi_0} = \left[\frac{x(1-x_0)}{x_0(1-x)}\right]^{\frac{P_1}{P_1-P_2}},$$

$$\frac{\eta}{\eta_0} = \left[\frac{x(1-x_0)}{x_0(1-x)}\right]^{\frac{P_2}{P_1-P_2}},$$

and

$$\frac{d\log\xi}{d\log\eta} = \frac{P_1}{P_2} = \text{constant}.$$

The last equation is readily recognized as Brown's formula, which thus appears as a special case of our more general relationship. The Brown-Young theory of distillation is, consequently, quite correct; but it applies only in the rare, almost exceptional, cases in which the vapor pressure curves are straight lines.

Other distillation studies carried on in these laboratories during the past two years dealt with the constant temperature still-head. On this work I hope to report in a future communication.

In conclusion, it is a pleasure to acknowledge my indebtedness to the Rumford Committee of the American Academy, for a grant without which our distillation work could not have been done.

Production of Tin Plate in the United States. ANON. (*Amer. Mach.*, xxxv, 168.)—Tin plate makes a new record in two or three particulars in United States commerce statistics for the late fiscal year. The imports are lower than in any year since the records began, the exports are larger than ever before, and for the first time the exports exceed the imports. The imports of tin plate fall below 100 million pounds. In the last six months of 1891 the home production was 2¼ million pounds. In 1892 it was 42 million pounds, and from that time on increased rapidly, and in 1897 exceeded 500 million, and in 1903 reached 1075 million pounds. In 1906 the production reached 1294 million pounds, and in 1909 it amounted to 1371 million pounds.

ELECTRICAL METHODS OF INTERCOMMUNICATION FOR MILITARY PURPOSES.[1]

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Major Signal Corps, U. S. Army.

THE Signal Corps of the United States Army maintains military lines of information by telegraph and telephone (radio, aerial wire, and submarine), by visual signalling, by air-machines, and by other collateral methods. It also devises and furnishes the electrical apparatus for the fire-control and fire-direction system of both the coast defenses and of field artillery. Incidentally it operates for commercial purposes military telegraph lines when such lines are not occupied with official business.

ALASKA.

The Signal Corps has constructed, and maintains and operates, the Washington-Alaska Military Cable and Telegraph System for official and commercial purposes. This system, at the present time, consists of 2,633 miles of submarine cable, 1,125 miles of land lines, and nine wireless stations. For purposes of administration and supply, the system is divided into four sections, with officers of the Signal Corps in charge. The lines from Valdez to Paxson comprise the first section, and are supervised by the Signal Corps officer at Valdez. The lines from Paxson to Glen, and from Fort Egbert to Boundary, together with the wireless stations at Fairbanks, Circle, and Fort Egbert, comprise the second section, and are supervised by the Signal Corps officer at Fairbanks. Those from Glen to Kaltag and the wireless station at Fort Gibbon comprise the third section, the officer in charge being stationed at Fort Gibbon; while the lines west of Kaltag and the wireless stations at St. Michael, Nome, and Kotlik comprise the fourth section, with the officer in charge stationed at St. Michael.

[1] Abstract of a paper presented at the joint meeting of the Electrical Section and the Philadelphia Section, American Institute of Electrical Engineers, held Thursday, October 12, 1911.

Below is given a list of stations and distances, corrected to date:

LAND LINES.

ST. MICHAEL–VALDEZ.

	Intermediate	Total
St. Michael	1	1
Golsova	42	43
Unalakleet	24	67
Old Woman	40	107
Kaltag	50	157
Nulato	37	194
Koyukuk	20	214
Louden	62	276
Melozi	29	305
Kokrines	37	342
Birches	38	380
Fort Gibbon	63	443
Rapids	36	479
Rampart	34	513
Glen	28	541
Hot Spring	22	563
Tolovana	32	595
Minto	42	637
Nenana	32	669
Chena	41	710
Fairbanks	12	722
Salcha	36	758
Delta	27	785
Richardson	12	797
McCarty	21	818
Donnely	36	854
McCallum	36	890
Paxson	19	909
Hogan	30	939
Gulkana	36	975
Copper Center	26	1,001
Tonsina	25	1,026
Teikhell	24	1,050
Beaver Dam	16	1,066
Wortmans	20	1,086
Valdez	19	1,105

NOME–FORT DAVIS.

Nome, city office	0	1,105
Nome, wireless	0.5	1,105.5
Fort Davis	4	1,109.5

EGBERT–BOUNDARY

Fort Egbert, wireless	0	1,109.5
Fort Egbert	1.5	1,111
Boundary (no station)	13.5	1,124.5
Fairbanks, wireless to city office	1	1,125.5

CABLES.

SEATTLE–SEWARD.

	Intermediate	Total
Seattle	0	0
Sitka	1,087	1,087
Valdez	599	1,686
Fort Liscum	4	1,690
Seward	196	1,886
Montague Island-Cordova-Cape Whitshed	69	1,955

SITKA–SKAGWAY.

Sitka	0	1,955
Cape Fanshaw (no station)	212	2,167
Juneau	98	2,265
Haines Mission	107	2,372
Skagway	18	2,390
Juneau–Douglas	3	2,393

CAPE FANSHAW-KETCHIKAN.

Cape Fanshaw (no station)	0	2,393
Wrangell	74	2,467
Ketchikan	113	2,580

LAWTON–WORDEN.

Fort Lawton	0	2,580
Fort Worden	40	2,620

WARD-LAWTON.

Fort Ward	0	2,620
Fort Lawton	13	2,633

SITKA–JAPONSKI ISLAND.

Sitka	0	2,633
Japonski Island	0.35	2,633

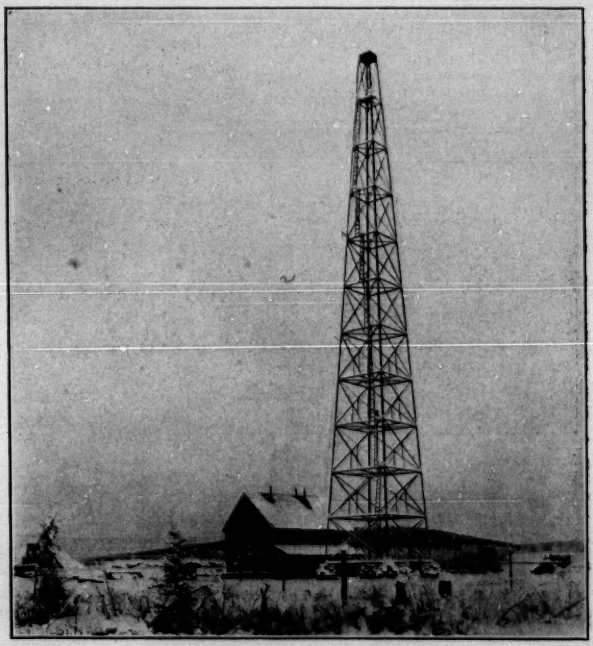
WIRELESS.

Egbert–Circle	110	.....
Circle–Fairbanks	126	.....
Egbert–Fairbanks	190	.....
Fairbanks–Gibbon	135	...
Gibbon–St. Michael	330	.....
Nome–St. Michael	127	.....
St. Michael–Kotlik	52	.....
Kotlik–Nome	122	.....
Petersburg–Wrangell	30	.....

RECAPITULATION.

	Miles
Land lines	1,125.5
Cables	2,633
Total	3,758.5

Wireless stations, 9.



Signal Corps wireless telegraph station at Fairbanks, Alaska. Part of a chain of wireless stations on the Yukon River.

RADIO-TELEGRAPHY.

The Signal Corps is responsible for the purchase, installation, and operation of wireless telegraphy for the army. The scope of this work requires widely different types of apparatus and

methods, from the light portable sets which are transported on muleback, for cavalry service in the mobile army, to the larger permanent stations along the Yukon River in Alaska and at the larger military posts in the United States. For strategical purposes high-power stations have been installed at Fort Leaven-

Signal Corps field wire telegraph section for use with infantry and mixed commands. The Manœuvre Division, San Antonio, Texas, May, 1911.

worth and Fort Riley, Kans., and Fort Omaha, and such a station is at present being constructed at San Antonio, Tex., which it is expected will have a range of 600 to 1,000 miles at all times. Below is given a list of the wireless telegraph stations installed by the Signal Corps, corrected to date:

UNITED STATES.

Name of Station	Call letter	Power k w.	Whether open to public service
Fort Andrews, Mass.	FC	1	Not open to public service.
Fort H. G. Wright, N. Y.	FW	1	"
Fort Hancock, N. J.	FN	1	"
Fort Leavenworth, Kans.	FL	3	"
Fort Levett, Me.	FV	1	"
Fort Monroe, Va.	FO	1	"
Fort Omaha, Nebr.	FS	3	"

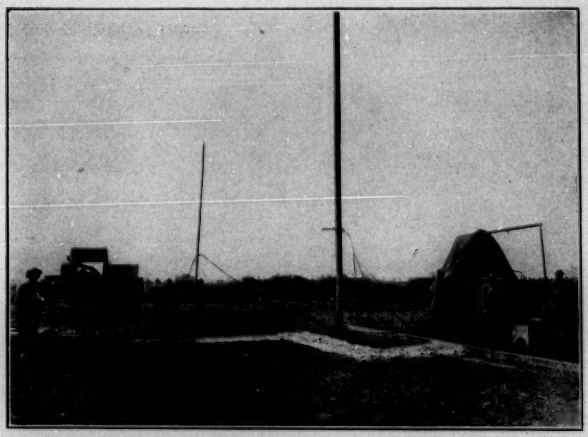
Name of Station	Call letter	Power k.w.	Whether open to public service
Presidio, San Francisco.	PS	1	Under construction.
Fort Riley, Kans.	FZ	3	Not open to public service.
Fort Totten, N. J.	FT	¾	"
Fort Wood, N. Y.	FD	3	"
Fort Worden, Wash.	FX	1	"
Sig. Corps Laboratory, Wash., D. C.	SC	3	Experimental.
Fort Stevens, Oreg.	FJ	1	Not open to public service.
Bureau Standards, Wash., D. C.	BS	2	Experimental.
ALASKA.			
Circle City	FK	3	Open to public service.
Fort Ebgert	FQ	5	"
Fairbanks	FB	5	"
Fort Gibbon	FG	10	"
Kotlik	FE	1	"
Nome	FD	10	"
Nulato	....	10	Under construction.
Petersburg	FP	1	Open to public service.
Fort St. Michael	FM	3	"
Wrangell	FW	1	"
PHILIPPINE ISLANDS.			
Corregidor Island	FH	10	Under construction.
Fort Drum	PIB	¼	Not open to public service.
Fort Frank	PIA	⅛	"
Manila	PN	1	"
Fort Wm. McKinley	PID	¾	"
Fort Wint	PIC	1	Under Construction.
U. S. ARMY TRANSPORT SERVICE.			
Buford	ATB	2	Open to public service.
Crook	ATC	2	"
Dix	ATD	2	"
Kilpatrick	ATK	2	"
Liscum	ATM	2	"
Logan	ATL	3	"
Sheridan	ATS	3	"
Sherman	ATR	3	"
Sumner	ATH	3	"
Thomas	ATU	3	"
Warren	ATW	2	"
Cableship Burnside	BS	3	"
Cableship Joseph Henry	FR	2	"
Cableship Cyrus W. Field	FA	1	"
ARTILLERY HARBOR TUGS.			
Captain Rowell	RW	⅛	Not open to public service.
Reno	X	½	"
General Randall	OR	⅛	"
General R. B. Ayer	FY	⅛	"
Harvey Brown	HB	½	"
James Fornance	ASF	⅛	"

PHILIPPINE ISLANDS.

At the outbreak of the Spanish-American war the Philippine Islands had no adequate telegraph facilities, and one of the first steps taken in the pacification of that country was to cover it with a net-work of wires and cables.

In 1900 the first American cableship, the United States transport "Burnside," was fitted out in New York harbor and dispatched to Manila, *via* the Suez Canal, laden with the first American-made submarine cable ever constructed for telegraph purposes.

During the years 1900 to 1903 this expedition connected all of the principal islands of the Philippine group and joined these cables to the extensive system of land lines which had been constructed by the Signal troops on duty with the American army



2 k.w. quenched spark field headquarters wireless set for communication with troops along the Mexican border. The Manœuvre Division, San Antonio, Texas, May, 1911.

of occupation. This system, when completed, comprised 6,322 miles of land lines and 1,437 miles of cable, which was maintained and operated by the Signal Corps for official and commercial purposes until 1907, when it was turned over to the civil authorities in those islands, where it is still rendering a most indispensable service. The Signal Corps retains, however, certain special lines for strategic and administrative purposes of the army.

SIGNAL SCHOOL FOR OFFICERS.

The Signal Corps maintains a technical school for the special training of officers of the regular Signal Corps and the line of the army.

The object of the Signal School is to prepare the officers of the Signal Corps for the better performance of the active duties of their profession, to provide instruction in signal duties for such officers of the line as may be designated therefor, to make researches and practical experiments in such subjects as relate to the duties of the Signal Corps, and to disseminate information so obtained.

This school is located at Fort Leavenworth, Kans., where is also the Army School of the Line, the Army Staff College, the Army Engineering School, and the Army Medical School. It enables the Signal Corps to most advantageously study, determine, and test the duties which would be required of it in campaign in conjunction with the other arms of the service.

SIGNAL SERVICE FOR THE MOBILE ARMY.

The one unchanging factor in warfare is the individual physical strength of a man. The soldiers of Cæsar's army were physically no stronger nor weaker than our own. Progress in the art of war, therefore, consists in the realization of certain fundamental conceptions from time to time, and the seizure of one idea at a time, working it out in detail, and applying it before an enemy realizes its importance. These fundamental ideas have been slow to impress themselves upon military leaders, and, therefore, that nation which first takes hold of a new fundamental principle in war, and works it out with the greatest perfection in time of peace, possesses an insuperable advantage when suddenly the conflict is precipitated.

Frederick the Great inherited an army which had been trained in peace, and he soon found out that he could march all around his enemies and strike them where he pleased. Napoleon, for the first time, grasped the importance of the relation between the ground and the battle, and developed this single idea until the French nation led the world in war. The electric telegraph was then unknown, but it is not too much to say that if there had been on duty with Napoleon's army at Waterloo a single

trained company of signal troops, such as is now at the United States Signal School, the history of modern Europe would probably have been different.

The strictly modern art of war began with the campaign of Metz and Sedan in 1870. The greatest of the fundamental ideas introduced in the art of war at that time concerned the mobilization and accurate assembling of great armies upon the field of battle. The army of the North German Confederation in the peace establishment numbered 12,000 officers, 285,000 men, and

Signal Corps wireless pack telegraph equipment for use with cavalry. The Manœuvre Division, San Antonio, Texas, May, 1911.

73,000 horses. The order to mobilize was telegraphed on July 16. Between July 23 and 25 the army was increased to 22,000 officers, 932,000 men, and 193,000 horses, ready for war. The mobilization having been completed in eight to ten days, in eight to ten days more a force of nearly half a million of men and 1,200 guns, with first and second lines of trains complete, was assembled on a line of about ninety miles from Treves to Germersheim, waiting for the order to advance. This result was effected by using railroad facilities to an extent unknown before.

GRAPHIC COMMAND.

The range and accuracy of modern artillery fire and the extended order in which troops at the present time operate have enabled us to form some rough estimate of the size and area of the modern twentieth-century battle-field.

With armies of the size which certain of the first-class powers may reasonably be expected to employ in a contest, the number of square miles which may be involved in the tactical use of such armies under one single command becomes so great that the military student is immediately confronted with the following serious questions: How is it possible for one brain or set of brains to be provided with efficient means of controlling and accurately commanding from hour to hour the vast assemblage of men and supplies which constitute the complex aggregation which goes to make up the modern army in the field?

It is certain that there must be some one supreme authority for such an army in order to secure that perfection of "team play" which lies at the bottom of all military success.

First. What means and accessories, therefore, can be provided by modern science to place in the hands of a supreme commander of an army the machinery which will enable him and his expert staff to digest the mass of military information which may be poured in upon him, not only from the operations of the troops themselves in combat, but also concerning the movements of the equally necessary supplies of all kinds which are required for the maintenance of that army? and—

Second. What sure and certain means may be furnished for the commander-in-chief to make the best use of this military information to direct the different units of his command from hour to hour over this vast area to effect an optimum in the co-operation of the three fundamental arms of which his command is composed?

In seeking an answer to the above military inquiries, we are forced to two general principles which are at the foundation of the solution of these questions:

(*a*) We must adopt the electrical messenger.

(*b*) We must assist the mind to grasp this complex and ever-changing panorama by the well-known advantages of graphics.

The electrical messenger has no competitor when the distances

involved in the modern battle-field are considered. It travels at a rate so great as to make all terrestrial distances equal for practical purposes, which means that the most distant point of the battle-field is equally near for purposes of command to any other point.

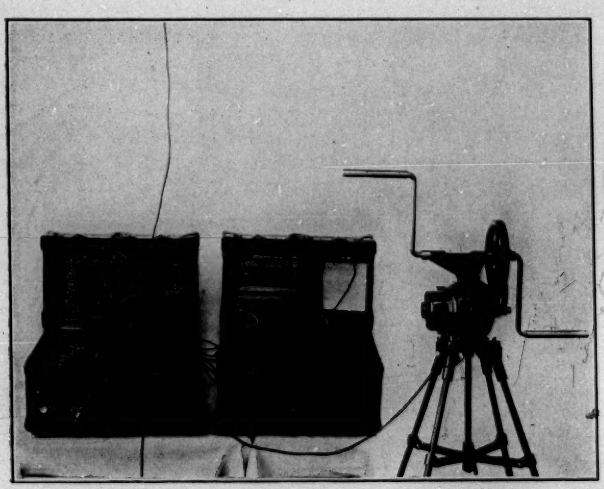
No human brain is able or brilliant enough to picture and follow in their relative positions the necessary elements of a large army, and the principle of graphics is the best known practical means at present to enable that brain to see his army in miniature in its ever-changing evolutions, and consequently to formulate effective commands to control these evolutions.

Having determined on the two fundamental principles which are necessary and sufficient in attacking the solution of this problem, it remains to develop them by long-continued practice in the field to the limit of possible usefulness. The perfection of these principles into a practical working machine by which the supreme commander, if need be, can command his forces, from a fixed point, may be called "graphic command" or "graphic control."

In the execution of "graphic command" for large forces in the field we are led to a conception of field headquarters radically different than was the case when great generals of the past operated their forces largely by commands given personally on the field. We may picture the commanding general of the future surrounded by his expert staff, each a specialist in his arm or staff department, occupying a more or less fixed point located in combat between his advance combatant troops in front and his supply train in rear. The exact location of field headquarters would depend on a number of circumstances, but evidently should be far enough removed from the actual fighting as to permit that calm and cool judgment on the part of both the commanding general and his staff which is a prime requisite at all times.

With large armies it would ordinarily be from ten to thirty miles in rear of the advance line, and in such comfortable buildings as the terrain affords. The commanding general should be carefully guarded from fatigue and provided with every means possible for his physical comfort. From this view-point it is even conceivable that a man may attain eminence as a general in the military profession at present without ever having been actually under fire.

During two separate manœuvre periods in the month of May, 1911, at Leon Springs, Tex., with the entire manœuvre division, the actual machinery of "graphic command" was carried out with marked success. Copies of the actual field messages sent and received, and the "graphic map" constructed by the Signal Corps, were turned over each day to the Chief of Staff after the



Field wireless pack set for cavalry operations. Power supplied exclusively by hand generator, shown at right of photograph. The two trunks are transported on a single mule. The Manœuvre Division, San Antonio, Texas, May, 1911.

completion of the manœuvre, and formed the "war diary" called for by Field Service Regulations.

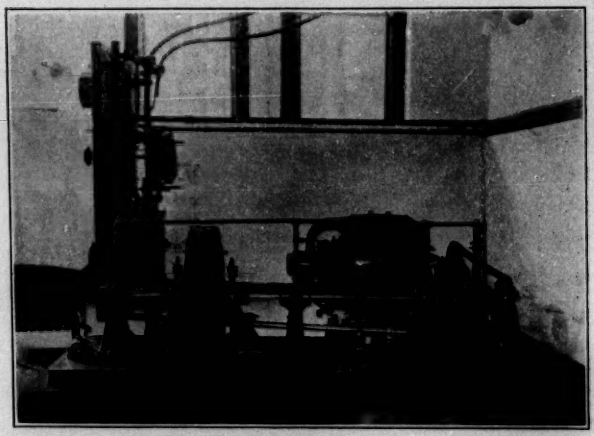
Wireless pack equipment was used invariably for cavalry operations, and field wire used for infantry and mixed commands, and all movements of the units were ordered by telegraph from temporary headquarters in the field and such movements plotted on the headquarters map by a signal officer.

SIGNAL CORPS RESEARCH LABORATORY, BUREAU OF STANDARDS.

In the development of special apparatus for the technical equipment of field companies for the mobile army, for fire con-

trol and direction of coast fortifications, and for wireless intercommunication at permanent and semi-permanent stations, the Signal Corps is constantly required to carry on engineering work of research character.

Under a special appropriation granted to the Signal Corps by Congress in the army appropriation act of 1909, a small research laboratory has been established at the Bureau of



100,000 cycle high-frequency generator. Signal Corps Research Laboratory, Bureau of Standards, Washington, D. C.

Standards, in the suburbs of the city of Washington. This laboratory is equipped with the latest forms of apparatus now employed in the wireless telephone and telegraph art, and also with the standard types of telephone and telegraph apparatus now used upon wire circuits. The small construction laboratory of the United States Signal Corps is located at 1710 Pennsylvania Avenue, and is also equipped with the usual types and forms of apparatus used in transmitting intelligence by electrical means. Each of these laboratories is supplied with a wireless telephone and telegraph installation with suitable antennæ. In addition, these two laboratories are connected by a standard telephone cable line about seven miles in length.

A special type of high-frequency alternator [2] is installed in the research laboratory, which has unique characteristics and enables experiments to be conducted through a range of frequencies of from 20,000 to 100,000 cycles per second. Attention is invited to this machine here for the reason that it is believed that this type offers rare opportunities for engineering research work to fill in the gap between wire telephony and telegraphy and pure radio-telephony and telegraphy. This generator is of the inductor type, and the rotor is a disk one foot in diameter, which revolves at a speed of 20,000 revolutions per minute to generate electric waves of 100,000 cycles per second.

The machine is intended to be used with a condenser, the capacity reactance of which balances the armature inductance reactance, which is 5.4 ohms at 100,000 cycles. This would require a capacity of about 0.3 microfarad for resonance at this frequency.

The air-friction or adhesion of this disk revolving at the above speed is over 5 k.w. or is greater than the total electrical output, which is 2 k.w., so that a 10 h.p. motor is required to operate it properly.

American Society of Mechanical Engineers.—The annual meeting of the society will be held in New York City, December 5–8 inclusive.

Business and professional meetings will be held in the Engineering Societies Building.

Several excursions and inspections have been planned; a lecture will be given on December 6, and a reunion will take place at the Hotel Astor on the following evening.

The Committee on Meetings is composed of Messrs. Fred. H. Colvin, Edward Van Winkle, Roy V. Wright, Frederick A. Waldron, and Walter Rautenstrauch.

Air in the Depths of the Ocean.—In a recent number of *Science* (August 25, 1911), Carl Hering suggests the following possible explanation of how air gets to the bottom of the ocean to support the life of deep-sea fishes and other living creatures who may need oxygen. The amount of gas which a liquid will hold in clear and stable solution increases with the pressure, as illustrated by champagne. The top layer of water in the ocean may be assumed to be

[2] Alexanderson, *Trans. A. I. E. E.*, vol. xxviii, p. 399, 1909.

saturated with all the air it can hold; the next layer beneath is under a higher pressure, hence holds more; there will, therefore, necessarily be a transference of air from the upper to the next lower layer to bring about stability. This process must continue downward to the most extreme depths at which the amount of air per unit volume would be greatest, because the pressure is greatest. The deep-sea fishes would, therefore, be enjoying richer air than those near the surface, and if they consume the oxygen, and the plants possibly the nitrogen, there should be a constant flow of air from the top to the bottom of the ocean.

The Extrusion of Metals in the Solid State. ANON. (*Iron Age*, lxxxv, 1507.)—Extruding means forcing the metal in a solid condition through a die by applying pressure behind the mass to be extruded. By extrusion zinc is transformed into a fine crystallized structure, with a tensile strength of 23,000 pounds per square inch, as compared with its ordinary tensile strength of 120 pounds per square inch. Aluminum, copper, and lead can be extruded with excellent results.

Selenium Photometer. ANON. (*Ges. für Elektrotechnische Ind., French Pat.* 425,854 of 1911.)—This is the type of photometer in which a rotating mirror, mounted obliquely to its axis of rotation, directs the light alternately from each of the two sources to be compared, on to a selenium element through which a continuous current is passed, this element being connected in series with two windings producing a magnetic field of constant direction, and in which a small coil, through which an alternating current is passed synchronizing with the alternations of the light falling on the selenium element, is suspended in this magnetic field so as to oscillate about the zero point when the lights are of equal intensity. In order to increase the sensitiveness of the instrument by using stronger currents, and at the same time to prevent the rapid oscillations of the needle, the field due to the continuous current passing through the selenium element is weakened by separate opposed windings or by a permanent magnet. In one arrangement the mirror, which has reflecting surfaces at both back and front, is mounted between two selenium elements. These elements are in independent circuits, having opposed windings, so that the variations of the field due to the two elements are in the same sense. The same effect may also be obtained using two separate mirrors. In another arrangement the selenium element is in the primary circuit of a transformer, and the secondary circuit contains two windings for producing the field in which the coil is suspended, through which the alternating current is passed. When the two lights are of equal intensity, there is no current in the secondary of the transformer and the needle of the suspended coil is in the zero position.

A BISMUTH-SILVER THERMOPILE.

BY

W. W. COBLENTZ, Ph.D.,

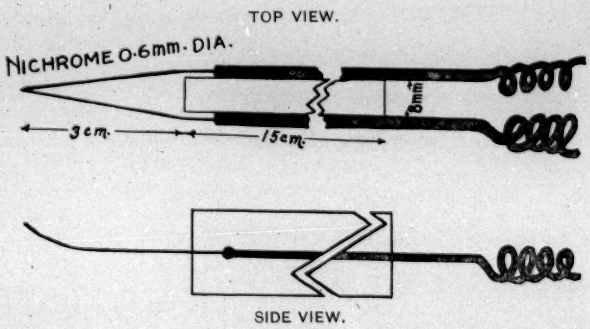
Associate Physicist, Bureau of Standards.

BEING able to purchase fine bismuth wire (from Hartmann and Braun), an attempt was made to use a pile constructed of bismuth iron, soldered with Wood's alloy. The iron was first tinned so as to make good contact. It was found that the resistance of a single junction arose from 1.5 ohms to 3 ohms, and some to 90,000 ohms, in a few days, and the whole was therefore discarded. In view of the fact that iron rusts easily, that the Bi-Fe junctions were weak, and that the thermoelectric power of Fe is about five times that of Ag, while its resistance is from six to ten times that of Ag, there is no particular advantage in using iron instead of silver. The welding of bismuth to silver makes a very strong junction. It was found that the direct welding of Bi to Ag was somewhat difficult. A small bead of tin, about 0.1 mm. in diameter, was therefore melted to the silver wire (Ag.=.051 mm. diameter) by means of a small heater of nichrome wire filed thin at the point, shown in Fig. 1. The end of the bismuth wire (Bi = 0.1 mm. diameter) was then brought into contact with this bead of tin (probably an alloy of Sn and Ag), which was then melted with the nichrome heater. Contrary to some of the prevailing notions, such a heater is better adapted to delicate work of this type than is a well-tinned soldering copper; for the surface tension of the molten material on the hotter surface of an ordinary soldering instrument is sufficient to tear fine bolometer strips. The bismuth wire is too brittle to permit flattening the junction, so that a small rectangle of pure tin 1.4 × 0.6 × 0.025 mm. was then placed under the Bi-Ag junction and fused thereto with a quick touch of the nichrome heater. It is somewhat easier to flatten the tin bead attached to the silver wire and then fuse the bismuth to this flat disk (see lower part of Fig. 2), but in this case it is not so easy to produce a receiving surface which completely fills the thermopile slit. Sheet silver, 0.02 mm. in thickness, is better than tin for a receiving surface.

because it does not melt in attaching it to the junction. In this case the tinned silver wire may be attached to the sheet of silver and then the bismuth wire is melted thereto.

There are many points in favor of the use of silver instead of copper in this type of thermopile. It is easily annealed and the brown oxide is easily removed by heating the wire on a sheet of metal. Thus cleaned, the bead of tin is easily attached without any soldering acid. A bit of rosin is useful but not necessary in attaching the bismuth wire. The low resistance (0.08 ohm

FIG. 1.

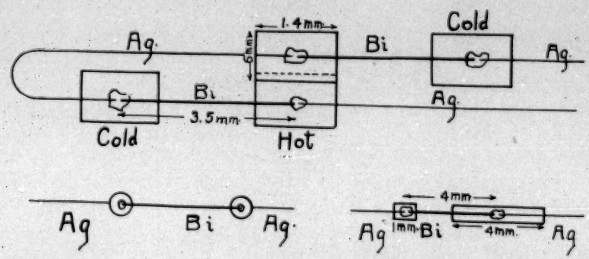


Nichrome welding instrument.

per metre), and especially the pliability of silver, are also important items, which one appreciates after working with iron and constantan wires. The bismuth wire is not so pliable, but it is short, and since it is subject to very little usage in mounting it is not easily broken. Before mounting them the various junctions were given a thin coat of shellac on the rear side, for insulation, and painted with a mixture of lampblack and chemically precipitated platinum black in turpentine on the front surface. The junctions were then mounted, slightly overlapping upon a glass plate, with Le Page's glue, and the ends of the silver wires were soldered together as shown in Fig. 2. The glass plate was then mounted on an ivory frame and the loose ends of the silver wires were attached thereto. The glass plate was then removed by soaking in water, thus leaving a uniform, solid, well-insulated

receiver as shown in Fig 3. Subsequently all these junctions were separated and the resistance of the pile was then found the same as when the junctions were in contact, showing that the insulation was perfect. The silver wires were then given a thin coating of shellac; but this was not necessary. The length of the receiving surface of this pile, consisting of 20 junctions, is 12 mm. The great width, 1.3 to 1.4 mm., of this particular pile was chosen for a special research in which high sensitivity was required. The rectangles or disks of tin may be much smaller, as in the new form of Rubens thermopile.

Fig. 2.



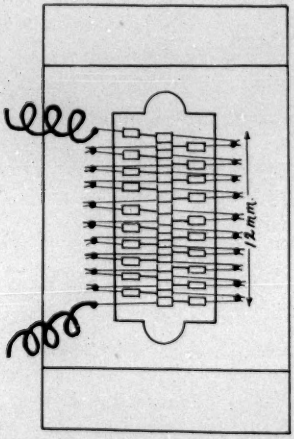
The thermoelectric power of this bismuth-silver thermocouple is 89 microvolts per degree, as compared with an iron-constantan couple which is 51 to 53 microvolts per degree. The *temperature* sensitivity of Bi-Ag is therefore about 74 per cent. greater than an iron constantan thermopile. Whether the *radiation* sensitivity is increased in like proportion will depend upon the selection of the proper diameters of wires, as will be found presently in this thermopile, in which the radiation sensitivity is two to three times that of the iron-constantan pile. The new form of iron-constantan thermopile of fine wires has a resistance of about 9 ohms. The present example of bismuth-silver has a resistance of 9.3 ohms.

The radiation sensitivity of this bismuth-silver pile and of an iron-constantan pile was tested, side by side, by joining the two instruments through a mercury switch to a galvanometer of 5.3 ohms resistance and $i = 4.6 \times 10^{-10}$ ampere. A standard sperm candle placed at a distance of 2.4 m. caused a deflection

of 10.2 cm., or 59 to 60 cm. for a candle and scale at 1 metre when the bismuth-silver pile was exposed. With a galvanometer sensitivity three times as large, as it is ordinarily used, the total deflection would have been about 180 cm.

The Rubens thermopile, of wires about 0.15 mm. in diameter and having a resistance of 4.7 ohms, when similarly exposed, caused a deflection of 3.8 to 4.0 cm, or about 23 cm. for a candle

FIG. 3.



Bi-Ag linear thermopile.

and scale at 1 m. The receiving surfaces of this pile were about 1.5 mm. diameter and about 0.2 mm. thick. The disks overlapped so that the 20 junctions occupied a space 20 mm. long. The actual area exposed was therefore greater than in the first bismuth-silver pile, which had a receiving surface of about 16 mm.^{2} This comparison shows that the radiation sensitivity of this bismuth-silver pile is about 2.6 as sensitive as the ordinary Rubens silver pile. If we consider that in spectroradiometry we are interested in the length (height) of the spectrum which can be utilized we should have made the length of the Bi-Ag pile 20 mm. by adding more couples. The radiation sensitivity of the

Bi-Ag pile would therefore be increased by 20÷12, or a total deflection of about 100 cm. instead of 60 cm. as observed. It is therefore safe to say that, comparing equal lengths of receiving surface utilized on a spectral line, the radiation sensitivity of this type of Bi-Ag pile is four times that of the old type of low resistance, iron-constantan pile. If we compare the bismuth-silver pile with the fine wire type of iron-constantan pile, which has a resistance of 8.9 to 9.3 ohms and has a radiation sensitivity of 1.4 times that of the old Rubens type of pile, it is a fair estimate to say that this pile has a radiation sensitivity three times as great as the new type of iron-constantan pile.

One important point usually not considered is the heat capacity, and hence the speed of attaining temperature equilibrium in these instruments. In the present radiation sensitivity tests the time of single swing of the galvanometer was 2 seconds. When joined with the bismuth-silver pile the half period was lengthened to about 3.8 seconds, which is practically the same as for the new type of fine wire iron-constantan pile. This is not an excessively long period, and the deflection returns abruptly to its zero position. But in the old type (heavy wire) of iron-constantan pile, tested alongside of the bismuth-silver pile, the time of single swing of the galvanometer was increased from 2 seconds to about 6.5 seconds, and there was a tendency to lag, especially when measuring intense radiation, so that it does not compare favorably with the Bi-Ag pile. This pile of bismuth-silver was designed for special work using a large receiving surface in air, where very thin metal is easily affected by air currents. The hot and the cold junctions are sufficiently alike in size and emissivity so that there is no permanent temperature difference and consequent drift in the instrument. The junctions are easily made and mounted, and they are equally easy to repair if broken. The iron-constantan pile of fine wire is difficult to handle and difficult to repair if broken.

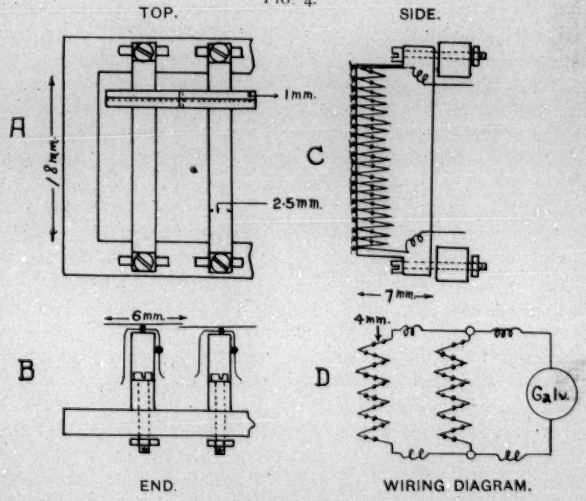
By using an alloy of platinum-iridium instead of silver the thermoelectric power would be increased, but owing to the increased resistance it remains to be determined whether a higher radiation sensitivity would be obtained.

The present instrument is not intended for rapid work, but for an exact and undisturbed register of observations with the instrument in air. While the time to attain temperature

equilibrium is somewhat longer (less than 4 seconds) than was hoped for, it is not sufficient to cause annoyance. By reducing the heat capacity, by using thinner wires, temperature equilibrium should be attained in less than 3 seconds.

The success attained with the linear pile led to the construction of a thermopile having a large receiving surface built up of single units, each of which contains 20 or more thermoele-

FIG. 4.



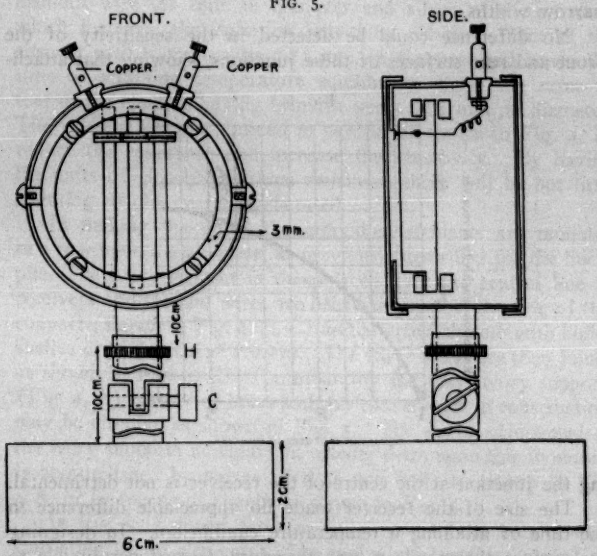
Surface thermopile of bismuth-silver.

ments, mounted upon an ivory support as shown in Fig. 4, C. In the preliminary tests as to the most desirable widths of strip to be used, thermoelements were built with receivers of the same width, 0.6 mm., and of different lengths, as shown in the lower part of Fig. 2. In all cases the silver wire used was 0.0513 mm. in diameter. The bismuth wires (4 to 5 mm. long) examined were 0.06 and 0.15 mm. in diameter. The two receiving surfaces were blackened, and they were exposed alternately to radiation. The elements to be tested were enclosed in order to avoid air currents. Using bismuth wire 0.15 mm. in

diameter, the deflection for a receiver 4 mm. long was not quite twice that of a receiver 1 mm. long. For both receivers the deflection did not attain a maximum abruptly, and there was a serious "creeping" requiring some 15 seconds for the galvanometer to come to rest.

Using bismuth wire 0.06 mm. in diameter the galvanom-

FIG. 5.



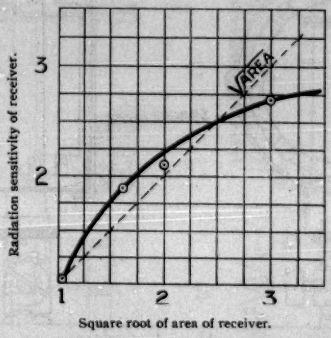
Holder for thermopile.

eter deflection for a receiver 4 mm. long was 2.1 times as large as that of the receiver 1 mm. long. On reducing the length of the 4 mm. receiver to about 2.6 mm. the sensitivity was 1.9 times as great as the receiver 1 mm. in length. A receiver 9 mm. long was 2.7 times as sensitive as that of a receiver 1 mm. in length. As shown in Fig. 6, the sensitivity varies roughly as the square root of the receiving surface, which is the law of the surface bolometer. As a matter of fact, there is an optimum length of the order of 2 mm.; but this exact value was not

determined. Obviously two receiving surfaces 4 mm. wide are better than a single one 9 mm. wide in the ratio of 4.2 to 2.7. In fact, the sensitivity would be still greater than this by placing two units (4 mm. wide) in parallel; for the internal resistance is reduced to one-half the former value. Units which are built up with receiving surfaces 4 to 6 mm. wide give ample working space in mounting, so that there is a distinct gain in using such narrow widths.

No difference could be detected in the sensitivity of the front and rear surfaces of these junctions, showing that attach-

FIG. 6.



ing the junction at the centre of the receiver is not detrimental.

The size of the receiver made no appreciable difference in the time of attaining a temperature equilibrium. In designing the surface thermopile it was therefore deemed permissible to omit the receiving surfaces from the "cold," unexposed junctions. For fine wire the deflection attained its maximum abruptly in 3 to 4 seconds.

In a vacuum of 0.15 mm. pressure of mercury the thermoelement of bismuth wire 0.06 mm. in diameter was 2.03 times as sensitive as in air. It is therefore a distinct advantage to place the pile in an evacuated enclosure.

Using the same size receivers, the radiation sensitivity of the thermoelement of bismuth wire 0.15 mm. in diameter was twice as sensitive as the element of bismuth wire 0.06 mm. in

diameter. But the serious lag in attaining temperature equilibrium in a thermopile of bismuth wire 0.15 mm. in diameter is objectionable, so that it is to be recommended only where a very high sensitivity is required and where the radiation is very weak.

In the surface thermopile it was therefore decided to use bismuth wire 0.1 mm. in diameter and silver wire 0.05 mm., which increases the radiation sensitivity closely to that of the element with bismuth wire 0.15 mm. in diameter and leaves the time of attaining temperature equilibrium about the same as that of the element having bismuth wires 0.06 mm. in diameter. The various elements, joined in parallel as shown in Fig. 4, D, reduce the resistance and increase the sensitivity. By having the units of closely the same resistance there will be but little shunting of the current generated.

In making the units, the individual elements are mounted in a row upon a glass plate, as previously described for the linear pile. The ivory support is then placed over the central line of receivers and the end wires are bent back against the side of this support (shown in Fig. 4, B, C) and attached thereto with boiled shellac or "Khotinsky" cement. The silver wires are then joined as shown in Fig. 4, C. The mounting for these ivory supports (Fig. 4, A) may be of brass and, for convenience in construction, may be circular as shown in Fig. 5. The slight adjustment of the ivory supports necessary in placing them upon this mounting is accomplished by means of slots and bolts as shown in Fig. 4 A, or by means of clamps as shown in Fig. 5.

In Fig. 5 is shown a surface pile made of three units, each consisting of 20 elements. The individual receivers are of tin 6 x 1 x 0.03 mm., and the total area is about 17 x 17 mm. Obviously the sensitivity to be attained depends upon the number of units, and this depends upon the patience one has in constructing such instruments.

The Rôle of Gelatine in the "Chemical" Development Process. A. P. H. Trivelli. (*Chem. Zentr.*, i, 958.)—The presence of gelatine increases the quantity of silver bromide that will be reduced by a definite quantity of developers, and retards the direct reduction of the fixed silver bromide, which gives rise to the developing film.

Subtractive Production of Artificial Daylight. H. E. IVES and M. LUCKIESH. (*Electrician*, lxvii, 297.)—In general, artificial illuminants differ from daylight by having an excess of red and yellow radiation in their spectra. Hence, by inserting a suitable screen in front of such sources, it should be possible to produce light of a color resembling daylight, and for many industrial purposes "artificial daylight" would be very serviceable, as it would facilitate correct color matching by artificial light. As daylight varies during the day, the aim is to attain average daylight. A combination of screens has been contrived reducing the various colors in the spectrum of the tungsten lamp to such proportions as to give a light very closely resembling daylight. A combination of cobalt blue and signal green glass, plus a gelatine film, colored with a suitable aniline dye, which weakens the intermediate yellow-green element, is found effective. Curves are given comparing the experimentally-determined transmission of such a screen with that theoretically ideal, and the resemblance is very close. An artificial "daylight window" is contrived on this basis.

Electric Steel Furnaces. F. DOUBS. (*Stahl and Eisen*, xxxi, 589.)—An Héroult furnace for 5 tons and one for 6 tons have been at work since 1909 and 1910, respectively, in a wire mill in Carinthia and a roller mill in Styria. Square electrodes caused trouble by burning unevenly, so cylindrical electrodes with water-cooled holders were substituted. The electric furnace can compete with the medium-size Martin furnace in the production of temper castings (iron to be annealed in an oxidizing atmosphere); but Martin furnaces would be more economical for producing soft steel on a large scale. Yet there are opportunities for electric steel furnaces in the Alps. The author, however, prefers three-phase Nathusius furnaces to the single-phase Héroult furnaces which require a rotary transformer. That the electrodes are imbedded in the hearth does not impair the strength of the Nathusius furnace.

Methane in Hungary. A. PÉCSI. (*Revue Scient.*, xlix, 6, 180.)—For some time it has been known that small sources of methane existed at different places in the great Hungarian basin. In some towns, such as Püspökladang, Arad, and Temesver, these natural gases are used for lighting, or for motive power in the factories. Recently large supplies of methane have been found in the Transylvania basin. The largest are at Kissármás, and in the vicinity of Marosvásárhely. Further search is being made under the direction of M. de Lóczy, director of the Royal Hungarian Institute of Geology.

SIMPLIFYING SOME THERMAL CALCULATIONS BY THE USE OF THE THERMAL OHM.

BY

CARL HERING, M.E.,

Consulting Electrical Engineer.

If a manufacturer is using a machine which does its work in a slow, intricate, round-about, complicated manner, necessitating that considerable attention be given to it, he would, if he were progressive, be very glad to adopt a new one, if it turned out exactly the same product but in a simpler, more direct, and more reliable way, with economy of labor and attention, and he would willingly scrap the old one, especially if the new one were presented to him. Yet when the machine is the man's own brain, and the work it does is to exert mental effort in performing calculations requiring thought and care, and involving at times great responsibilities, the average man will continue to work in the rut dug by his forefathers, rather than to adopt improvements that are offered to him gratis, which have for their object economy in brain work, or what may be called the conservation of mental effort.

As an illustration, a vast amount of such mental effort is being absolutely wasted daily by millions of people in Great Britain by the use of their senseless, antiquated, irrational but beloved £ s. d. We in this country could appreciate it, if we were to think for a moment of what a mental tax it would be to us, in our daily finances, to change back from our decimal system to the awkward, antiquated English one. Similarly, the people in the more progressive nations like Germany and France, who have adopted the decimal system in all their other measures, can use for other and really profitable purposes the vast amount of brain labor and mental effort which we in this country are wasting daily with our awkward and cumbersome system of weights and measures, which they look upon as being as absurd as we think the English money system is. It is no wonder, therefore, that such magnificent mental work issues from those

more progressive countries in which man's brain is not hampered and fatigued by the wasteful mental brake which it has applied to it incessantly, as it is in this country and even to a still greater extent in England.

In an article in the February, 1911, issue of this journal, page 129, the writer made an analysis of systems of measures and called attention to numerous improvements that could be made with a view to economy in mental effort in performing calculations such as an engineer has to make daily. It was there shown that the physicist has the great advantage in using the so-called absolute or *c.g.s.* system, in which there is one, *and only one,* unit for each physical quantity, and in which nearly all coefficients and conversion factors drop out of the calculations because they are unity; and that it would be quite feasible for the engineer to benefit by the use of a similarly ideally simple system by merely adopting as his working units decimal multiples or fractions of the absolute units, as in fact the electrical engineer has done in his excellent brain-saving system of electrical units. It would even be of more importance to the engineer than the absolute system is to the physicist, because he has vastly more calculations to make, and they are often of greater importance, as mistakes in them in designing engineering structures may cost the lives of innocent people.

Although such means for economizing mental effort are offered to us gratis, the average man is like the manufacturer who prefers to continue to use antiquated machinery rather than to scrap it and accept the better one that he can obtain without cost. He complains that it is too much trouble for him to move away the old machine and set up the new one, as his more progressive neighbor does. The natural result is that the one gets the trade while the other is fossilizing. It is not surprising, therefore, that, in accordance with the law of the survival of the fittest, a progressive country like Germany, where the economy of mental effort enables that effort to be more profitably applied, is fast getting the world's trade from its neighbor who is burdened with a fossilized system of mental brakes in the shape of absurdly complicated, brain-robbing systems of measures, almost all of which we had the misfortune to inherit from England, and which we cling to as the unprogressive manufacturer clings to his antiquated, out-of-date machine.

Although it may, unfortunately, take us several generations more before we succeed in giving up our cumbersome systems of measures, and adopting the decimal systems, yet there are some directions in which we can save mental effort without parting with any of our beloved antiquities, namely, by adopting some new and rational units or measures where none existed before.

The purpose of the present article is to show how, by the adoption of a new unit for a quantity for which no unit has existed, the mental labor in a certain class of calculations can be greatly simplified and reduced.

In general, when no definite unit exists, we naturally refrain from using that quantity by adopting some round-about methods, or, when we must use it, we have to define a unit of our own—a home-made unit, as it were—which generally results in different writers giving their data in different units, thereby causing the waste of much mental effort by the one who desires to combine and use such data from different sources. In a recent case of this kind, an author of an otherwise excellent paper had made up such a home-made unit, quite different from all the others, in terms of which his valuable quantitative results were given, but had carelessly omitted to give the receipt according to which that complicated unit had been concocted, and it cost the present writer the best part of a day to work out its composition before the data became available, all of which mental effort could have been saved had the unit been described, or, better yet, had there existed a well-defined, recognized, international unit for measuring that quantity.

One of the groups of calculations in which no definite units exist for certain quantities is that concerned with the flow or transmission of heat by conduction, convection, and radiation. It therefore concerns such calculations as the thermal insulation of steam or refrigerating pipes, of electric and other furnaces, the transference of heat from the flames to the water in boilers, or from the flames or the arc of a furnace to the metal to be melted, the insulation of thermos bottles, the cutting of metals with flames, the repairing of broken metal machines by local fusion, etc.

For measuring heat energy itself, statically, plenty of units exist; too many, unfortunately: the large calorie, the small

calorie, the B.T.U., the mongrel pound-centigrade unit, the joule, and the erg, some of which have several names; in name there exists a seventh, the "heat unit," which may mean nearly any of the others, according to the fancy of the writer, and is therefore meaningless unless defined by the user.

When a flow of heat is involved, that is, a rate of transmission of heat, the element of time must be introduced, and here there is again the choice of the hour, minute, or second, according to the fancy of the writer. Six heat units combined with three time units make eighteen possible units of heat flow, from among which different writers seem to delight in choosing that one which they think other writers have slighted. However, each one of this family of eighteen would be an intelligible unit for expressing a flow of heat if its particular make-up is clearly specified by its particular admirer.

Flows of heat through bodies are conducted, and they then meet with more or less resistance in that body, which resistance, for instance, is said to be about twenty or thirty thousand times as great through a piece of flannel as it is through an equal piece of copper. And as this thermal resistance varies so greatly and is of great importance, it becomes very desirable, and sometimes even necessary, to use it as a quantity capable of being measured, calculated, and specified; hence there should be a unit in terms of which this can be done. But no such unit existed, and the consequence is, as usual, that an author either evades using this quantity, or else makes up a unit of his own; this results in a great multiplicity of units ambiguity in their meaning, and, in general, much wasted mental effort on the part of the one who has to apply the data to practical cases. Some authors seem to take particular pleasure and pride in making up new composite units in such cases, and sometimes the only originality in an article is the invention of a different unit which no one else has cared to use.

Thermal resistances have in the past been generally avoided by using the reciprocals instead, namely, conductances (often incorrectly called conductivities, which are really specific conductances). But in by far the most cases in practice a flow of heat passes through several bodies in succession, that is, in series, as the electrical engineer terms it. Even in simple cases there are generally several successive contact resistances in series with

that of the material itself, and these are sometimes extremely high; in fact, at times the most important of all, as in steam boilers, for instance, in which by far the largest part of the virtual thermal resistance is at the contact of the flames and the outside of the water tubes; this is so very great that the difference between the resistance of copper and iron tubes (about 4 to 1) falls into insignificance.

When heat or electricity flows through several bodies in series it is far simpler to use resistances in the calculations, instead of conductances; and when they are in multiple the reverse is the case. The former being by far the more general case, it is much more rational to use thermal resistances than the older and more common conductances. This is the first of the improvements which is here recommended for the purpose of economizing mental effort in such calculations.

But in view of the fact that conductances have in the past been used almost exclusively, let us consider for a moment the question of the units of conductance and conductivity. Such units are composite and must be made up, and this particular case is a good illustration of how each writer is apt to make up one of his own without the slightest regard for uniformity. Moreover, it seems that no one, until recently, has ever suggested a unit of conductance itself, but only of conductivity. Notwithstanding the convenience which the former would be, let us consider here only the latter.

A unit of conductivity is defined by a certain flow of heat through a specified cross section for a specified length, hence involves areas and lengths. For the latter the physicists usually take the square centimetre and the centimetre, hence they specify the heat flow through a centimetre cube; yet the inch is also often used, and until we have abandoned this irrational unit it is convenient to give conductivities in inch cube units also. Besides these two, some writers also use the metre cube, others the square foot combined with one inch thickness, etc.; in one noted case of an otherwise excellent article descriptive of some valuable research work, the author of it even introduced the inexcusable mongrel combination of one square metre area with one inch thickness. But assuming that there are only four sets of these linear and superficial units, then with the 18 different possible units of heat flow mentioned above this makes 72 pos-

sible units of thermal conductivity—enough for the most fastidious writer to choose from if he wants something different from what others use; something "original."

This absurd and deplorable state of affairs, and the waste of mental effort which it involves, led the writer some time ago to investigate the subject with a view to finding, if possible, that unit in each case which is at the same time the most rational and reduces the calculations to the least possible.

As stated before, the units used in the absolute system are those which bring nearly all coefficients to unity, hence involve no troublesome conversion factors. Hence, whenever we are in want of a new unit it is best to go to this absolute system, and, as the units in that system are often inconveniently small or large, to take some decimal multiple of them. This is what was very wisely done when our system of electrical units was devised, and those who enjoy the simplicity of electrical calculations should be thankful to our forefathers for their good judgment and wisdom.

A flow of heat is a particular case of the transmission of energy, the particular one in which the transmitted energy is in the form of heat, but as it may be transformed from or into other forms of energy, it is best, in the selection of a unit, to consider energy in general, and not only one form of it. The unit of energy in the absolute system is the erg, which is equal to the force of a dyne acting through a centimetre. The unit of time in that system is always a second; hence the absolute unit for measuring a transmission of energy of any form is an erg per second. This being inconveniently small for practical work, it has been decided, for electrical purposes at least, to make the practical unit ten million times as great, and this unit is known as the watt.

Hence the most rational unit for measuring a flow of heat is the watt. To say that the heat flow in a certain case is so-and-so-many watts means that the amount of heat is that which would be set free if that many watts were converted into heat, as in an electrical heater, for instance. Hence, if this unit were used, all coefficients and reduction factors would drop out (or be some multiple of 10), at least for all calculations with electrical quantities, such as electric furnaces or heaters, etc.

As a watt is a joule per second, the coefficients and con-

version factors would also drop out in all our heat calculations if the tables of thermal constants were reduced once for all to joules. Specific heats, which are generally given relatively to water, would then be given by their true, absolute values in joules. But such a revolutionary change as that, which would involve the dropping of all four of our "home-made" units of heat, for which we seem to have such an affection, and using only the two natural or absolute ones, the erg and joule, is foreign to the present paper and need not be further discussed here.

Having found that the most rational unit of heat flow is the watt, and having decided that thermal resistance was a more generally useful quantity than conductance, the next question is, What is the correspondingly rational unit of thermal resistance? It is evidently that one which again reduces the coefficient to unity. The law of heat flow is, that the amount of flow increases in proportion with the temperature drop (which causes the flow) and decreases in proportion with the resistance (which opposes the flow); hence just like with electricity. This might be termed the thermal Ohm's law; or, represented by letters, if W is the heat flow, T the temperature drop, and R the thermal resistance, then $W = T/R$. It is in this fundamental law that the coefficient is to be made unity.

In the absolute system of units there is no temperature scale, as temperature has not yet been reduced to absolute measure. Hence, until it is, we are compelled to use some one of the artificial temperature scales, and among these the centigrade is certainly the more rational and the most commonly used in most countries and to a gradually-increasing extent in this country.

Hence, as T is to be in centigrade degrees and W in watts, it follows that the unit for the thermal resistance R must be so chosen that the coefficient in this law will be unity. Hence R must be made equal to that thermal resistance which will allow one watt to flow when the temperature drop is one degree centigrade; this is the unit that the writer has termed the thermal ohm, a name originally suggested by Dr. A. E. Kennelly, for thermal resistance, though for a quantitatively different unit.

Hence, when the physical property of a given body through which heat is flowing is stated in thermal ohms, and the temperature drop in centigrade degrees, the quotient of the latter by the former will give the heat flow in watts directly without

any further reductions. It has therefore been reduced to the simplest possible kind of a calculation.

For calculations involving electric heat, such as those concerning electric furnaces and heating devices, nothing simpler could be desired, but even in other cases it will often be found to be simpler to make the calculations in thermal ohms and watts, and merely convert the final result back to the older and more cumbersome units, in which it may be desired.

The physical property of materials, called resistivity (specific resistance), as given in tables, is then stated in thermal ohms for one centimetre cube or one inch cube, and with the aid of these the total resistance of any given block of material is determined just as for electrical resistance, namely, by the usual formula $R = rL/S$, in which R is the total resistance in thermal ohms, r the resistivity in thermal ohms, L the length and S the section, centimetres or inches being used consistently throughout.

The use of thermal resistances as such, in calculations, is often a great convenience and time-saving device. For instance, in determining the insulating walls of electric furnaces the temperature drop is known, and so is also the allowable loss in the form of a percentage of the total input. The former divided by the latter then gives the resistance which the walls must have in thermal ohms. With the resistivities of the various materials and the inside dimensions of the furnace, the thickness of each layer of the different materials making up the total wall can then be calculated so that the sum of all the resistances is equal to that required. This would be an extremely tedious calculation to make with conductances. The temperature at the junction of any two layers can then also be readily calculated with the same formula; W and R being then the known quantities, T is equal to their product.

In the insulation of steam pipes the temperature drop from the inside to the outside is known, and the permissible loss in power (reduced to watts) is decided upon; their quotient then gives the total insulation resistance in thermal ohms, hence per foot or per inch of pipe. Knowing the resistivities of the various insulating materials, the thickness of each can then be readily calculated, hence their respective costs, which can then be properly compared. It may thus be found, for instance, that it is cheaper to use a thin layer of a better insulator than a

thick layer of a poorer one, or the reverse; or perhaps that a combination of two layers is better. For thick layers over small pipes the outer layers count for much less than the inner.[1] Several such trial calculations would show to what extent the value of the steam energy which is being saved is worth the cost of saving it. In such cases the reduction to and from watts is made once for all, the simple Ohm's law being then available for the more numerous trial or comparative calculations.

For a certain limited class of simple calculations involving steam or fuel energy alone, when the physical constants are available in the best form for direct application, it may be more convenient to use the older method based on conductivities and without reducing to watts; but when anything different from the ordinary is involved, it will probably be found to be simpler to perform the computations in terms of watts and thermal ohms, and reduce merely the end results to the units desired, just as it is often simpler, in the more involved calculations, to reduce values to the metric system, perform the calculations in that system, and convert the end result back to our old units. It is also possible, of course, to establish other units of thermal resistance, based on the particular thermal temperature, time and length units, which one may be accustomed to using, by a method which reduces the coefficient to unity, similar to the one here used to establish the thermal ohm.

Another advantage of such a unit as the thermal ohm is that, being based on the absolute system, it is a rational one to which all values determined in other units could be expected to be reduced by the authors, hence it could be used as a sort of standard international thermal unit in terms of which all determinations can be readily compared, and from which they can readily be reduced to any other specific units desired; a sort of clearing-house for the 72 possible units of resistance.

Attention is here called to the fact that in not a few books and papers the heat flow and thermal conductivity units based on the gramme calorie per second, centigrade, and centimetre cube are claimed to be the absolute units. This is an error, although a very common one; this can be shown by the fact that they are incommensurate with the true absolute units. There

[1] See an article by the present writer in the *Electrical World*, November 25, 1911, page 1303.

is no heat unit in the absolute system; heat is energy, and the energy unit in that system is the erg and not the gramme calorie. The units recommended by the writer (watt and thermal ohm) are the ones which are the decimal multiples of the true and correct absolute units, and they are incommensurate with the so-called absolute units just described.

A table of about 150 values of the thermal resistivities of different materials, taken from various sources and reduced to thermal ohms by the writer, is being published in the December issue of *Metallurgical and Chemical Engineering*. The values in centimetre cube units range from about 0.24 to about 3 for the metals; 25 to 180 for various bricks and solid stones; and from about 250 to 5000 for granular or fibrous materials mixed with air. It will therefore be seen that the unit is of a convenient size.

A table of conversion factors for reducing the various units of thermal resistances, conductances, resistivities and conductivities to one another is given in the writer's paper on the thermal ohm, in *Metallurgical and Chemical Engineering*, January, 1911, page 13.

Density of Niton (*"Radium Emanation"*). R. W. GRAY and W. RAMSAY. (*Roy. Soc. Proc. Ser.*, H.84,536.)—The balance used to weigh the niton (RaEm) was sensitive to 2 micro-milligrams and acted on the same buoyancy principle as that of Steele and Grant, but certain modifications were introduced. Five experiments were made to determine the atomic weight of niton; the mean result was 223. The amount of helium produced by the niton and its products on complete disintegration to RaD was determined by weighing, and the result agreed closely with the disintegration theory, although about one-fourth of the helium had entered the walls of the weighing-tube and had to be expelled by heat and subsequently weighed. The experiments afford further proof of the disintegration theory on which the weight of niton should be 222.4 (Ra 226.4—He 4).

Temperature of the Sun. F. KURLBAUM. (*Preuss. Akad. Wiss. Ber.*, XXV, 541.)—By a spectroscopic comparison of sunlight with a standard lamp, a series of determinations of the solar temperature have been made. The mean result is given as 5730° abs. by the Holborn-Day scale or 6390° abs. by the Holborn-Valentiner scale.

MODERN USES AND APPLICATIONS OF RADIUM.[1]

BY

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WHEN Professor Roentgen discovered the Roentgen or X-Ray, it was generally believed that the powerful and penetrating rays emitted by the so-called Roentgen tube *were produced or emitted* by the bright fluorescence which constantly appeared when the Roentgen tube was in operation. This belief in the creation of these powerful rays by the fluorescence caused most of the physicists who were investigating this field to experiment with a great many fluorescent materials in order to determine whether similar powerful rays were emitted by any such materials. Among these investigators was Professor Becquerel, of Paris, who one day, after experimenting with some fluorescent uranium salts, not being able to finish his experiments that day, placed the uranium salts in a drawer of his desk. After several days, upon opening the drawer and seeing the uranium salts, he determined to continue his experiments. When he removed the uranium salts he saw that, by accident, they had been resting during this period upon a photographic plate contained in a securely-sealed envelope, such as is generally used for X-Ray and similar purposes. Becquerel then determined to develop this plate for curiosity's sake, and found to his great delight that the plate had been strongly affected by radiations of some kind. This led to further experimentation with uranium materials, leading finally to the discovery of what are now known universally as the Becquerel rays.

Madame Curie then took up the investigation of these uranium salts and soon found that pitchblende, the ore from which uranium is extracted, emitted the same radiations as the uranium salts, only in a far larger proportion. Madame Curie then obtained from the Austrian Government, which controls the

[1] Abstract of a paper presented at the stated meeting of the Institute, held Wednesday evening, September 20, 1911.

Bohemian pitchblende mines, some of the refuse of the pitchblende ore after the uranium had been extracted, and she found that this refuse was far more radioactive than either the uranium or pitchblende themselves. This convinced Madame Curie that pitchblende contained something which emitted powerful rays, apparently independent of the uranium. Further investigation led to the discovery of what Madame Curie at that time believed to be a new element, which she named Polonium, after the country from which she came. This Polonium emitted a very large quantity of radiations, which, however, were of very low penetrating power. It has since been found by Prof. Ernest Rutherford, at that time of McGill University, now of Manchester, that Polonium is not a primary radioactive element, but simply a disintegration product of the radium emanation, to which I shall refer later.

Madame Curie continued her investigations and soon found that the pitchblende refuse contained still another element which emitted the same radiations as Polonium, besides various other radiations of far greater penetrating power. This element Madame Curie named radium.

Experimentation at first led physicists, especially also Madame Curie, to believe that radium emitted three kinds of rays, which, for convenience, were called the alpha, beta, and gamma rays. The alpha rays are of very low penetrating power. They are absorbed even by tissue paper or very thin sheets of aluminum. The beta rays, which greatly resemble the Goldstein or Cathode rays, are of far greater penetrating power. Lastly, the gamma rays, which greatly resemble the Roentgen or X-Rays, are of tremendous penetrating power. I personally have been able to obtain fine photographs with these rays through twelve inches of steel.

The study of this new element was then universally taken up by physicists all over the world, and especially have the investigations of Prof. Ernest Rutherford been exceedingly fruitful. Rutherford soon found out that radium itself emits but one radiation, and that is the so-called alpha ray. But, besides this radiation, radium emits a certain gas which is called the emanation. These emanations were found to decay rapidly, and while decaying form a new product, which product also disintegrates or decomposes and in doing so forms another product, which

likewise is subject to the same change, and so on. The various disintegration products themselves emit certain radiations, and the process of this disintegration, as determined by Rutherford, is as follows:

Radium, as stated before, emits the alpha rays, which in reality are small particles of matter that can be detected when the naked radium is exposed to a zinc sulphide screen, as the bombardment of the screen by these particles, which travel at a remarkable velocity, produces scintillations which look like millions of shooting stars or sparks under a magnifying glass. Through the constant giving off of particles the radium atom gradually breaks up, but this is so slow that only one-half of the atom is broken up in about 1,300 years. Besides these alpha particles, radium emits a certain gas, which, as the writer has stated before, is called the emanation. The emanations are very unstable, one-half of them breaking up in about 3.8 days. The emanations themselves emit only alpha rays, and, as said before, rapidly decay, and while decaying form a new disintegration product, which Rutherford has named radium A. Radium A is the most unstable of all the emanation disintegration products, one-half breaking up in about three minutes. Radium A emits only alpha rays, and when breaking up forms another product, which is called radium B. Radium B emits no rays and is transformed in twenty-six minutes, whereby is produced radium C, which is the most remarkable of all the disintegration products. For radium C emits all three kinds of rays, namely, the alpha, beta, and gamma rays. Radium C is also transformed, and during this transformation the alpha particles which are emitted are expelled with much greater velocity than the alpha particles of the other radium products. These alpha particles are absorbed only after traversing 7 cm. of air, while the alpha particles of the other radium products are never able to penetrate more than 4.8 cm. of air. Besides these alpha particles, the beta and gamma rays are emitted, which are of very much greater penetrating power. Radium C, when decomposing, forms a radioactive residue, which is called radium D. Radium D is far more stable than the other radium products, but it does not emit any rays. Radium D also decomposes and forms radium E, which emits only beta and gamma rays. The life of radium E is short, and its disintegration product is radium F. Radium F is the final radioactive

product of radium. It is an element of high atomic weight and is identically the same product as that which Madame Curie discovered at first and named Polonium. It is also the same product which Professor Marckwald, of Berlin, discovered and named radio-tellurium. Radium F emits only alpha particles, but a far larger quantity of these than is emitted by any of the other radium products. Radium F is half transformed in 143 days.

If a quantity of radium emanations is left in a glass tube for some time, the glass will be covered by a radioactive deposit which can be dissolved in diluted H_2SO_4. If this solution is kept for a long time, say about a year, the activity of same will be found to have steadily increased. If polished bismuth discs are dipped into such a solution, this radium F may be deposited upon them electro-chemically, and, upon removing the discs, will give off only the alpha rays but no trace of beta rays, and this very fact led Marckwald to believe that he had discovered a new element, which he called radio-tellurium.

Besides radium, there have been found other radioactive elements, especially thorium. Thorium is the element from which the so-called Welsbach gas mantles are made. Another radioactive element has been found which is known as emanium; it has been named emanium on account of the great quantity of emanations it emits.

As previously stated, radium is found in pitchblende, the ore from which, in Bohemia, the uranium is extracted. Uranium is used very extensively in the manufacture of Bohemian glassware. After the uranium had been extracted from the ore, the so-called refuse was thrown away, and only since the discovery of radium has this refuse become an extremely valuable product.

However, radium does not appear only in pitchblende, but it appears in any ore that carries uranium, as radium itself is only a product of the decomposition of uranium, and the quantity of radium which is contained in the ore is in direct proportion to the quantity of uranium contained in that ore and can be correctly measured thereby. We have pitchblende in the United States, and it is found especially in Gilpin County, Colorado. Carnotite is also found in Colorado and in some other States. Both of these minerals carry large quantities of uranium, and consequently radium. Furthermore, minor quantities of radium have been found in the so-called monazite sands of North and

South Carolina. These are the same sands from which also the radioactive element thorium is extracted.

When radium was first introduced to the scientific world, it appeared as a grayish-yellow powder, in small, irregular crystals, and on account of its tremendously high cost was contained in small, hermetically-sealed glass tubes or vials. It must be remembered that radium itself emits only the alpha rays and emanations. The emanations and their subsequent disintegration products also give off alpha rays, and, later, beta and gamma rays. The alpha rays are of exceedingly low penetrating power and the emanations are of practically no penetrating power; but of all the radiations given off by radium and its subsequent disintegration products fully 95 per cent. consist of the alpha particles, whereas the remaining 5 per cent. consist of combined beta and gamma radiations. As radium formerly was contained only in hermetically-sealed glass tubes, all the alpha radiations, all the emanations, and even a part of the beta radiations were absorbed by the glass tube, and therefore when radium was applied in such tubes only a very small percentage of its total radiations, that is, a part of the beta rays and the gamma rays, could be utilized for physiological and other purposes. This led the writer, after due experimentation, to invent aluminum containers, that is, small containers of exceedingly thin aluminum sheets, which could be hermetically sealed by a suitable device. These containers had the advantage over the glass tubes in that they would permit all of the beta and all of the gamma rays to penetrate them; but even these extremely thin aluminum containers would absorb all the emanations and all of the alpha rays or particles. At that time it was despaired of ever being able to utilize the alpha rays and the emanations as valuable therapeutic agents. After long experimentation, and knowing and appreciating fully the importance and necessity of obtaining radium in such a form that access could be had to the emanations as well as to the alpha radiations, and especially considering the fact that even in naked radium we are able to utilize only those alpha radiations and emanations which are emitted by the direct outside layers of a radium particle, as those emanations and alpha radiations emitted by the under layers are unable to penetrate the upper layers, and knowing that for the utilization of these alpha particles and emanations the radium to be utilized would

have to be with practically no under layers, the writer succeeded in finally constructing what are now known as "radium coatings." Radium coatings are manufactured as follows:

Radium is dissolved in a suitable solvent. This suitable solvent must of necessity vary in accordance with the substance which is to be coated. Thus, if a metallic substance is to be coated, the solvent should contain a certain proportion of an acid which is able to affect the surface of the material to be coated. If celluloid (which the writer preferably employs) is used, the solvent should contain such ingredients which are capable of softening and affecting the surface of the celluloid, and for this purpose the writer employs largely ether, wood alcohol, acetone, amyl acetate, etc. After the radium has been thoroughly dissolved in these solvents, the proper dissolving of which requires considerable care and experience, as the slightest amount of residue would entail a comparatively large financial loss, the material to be coated, usually either rods or discs, is dipped into the solution. Or, if dipping is not advisable, that part of the material which is to be coated is covered with a small quantity of the radium solution by means of a pipette. As stated before, this radium solution contains, dissolved therein, the radium usually in the form of either radium bromide or radium chloride of varying activities. Naturally the radium solution should be spread as evenly as possible upon the surface to be coated. Then the solvent is allowed to evaporate, which leaves the radium spread in a thin film all over the article to be coated. Since in the case of celluloid the solvent has the tendency to soften and dissolve part of the surface of the article, the deposited radium is thoroughly imbedded in the surface, whereby is fulfilled one of the principles desired, namely, to produce practically nothing but a surface of radium with as little radium as possible in underlying layers. However, if radium were used in this form for physiological purposes, it would be of very little value, for if these radium-coated rods or discs were brought in contact with any liquid or would be inserted into a diseased part and come in contact with the blood or juices of the human or animal body, the radium would completely dissolve and it would cause a complete loss of the material. It was therefore necessary to protect the radium film against loss through solution or mechanical friction, etc. This, however, was a very difficult problem, be-

cause of the fact that the main object was to obtain full access to the alpha radiations and the emanations, for if the writer had simply coated these so-produced instruments with a protective coating the alpha radiations and the emanations would certainly have been absorbed by the coating, owing to their extremely low penetrating power. It therefore was necessary to construct a coating which would answer both purposes, namely, be thin enough so that the alpha particles and the emanations could penetrate same, and at the same time be tough and protective enough to protect the radium filament from solution in the liquids with which it might come in contact and from mechanical destruction by friction, etc. The writer finally succeeded in doing this by gradually applying coatings of specially-prepared collodion solutions. These collodion solutions must vary in accordance with the material which has been coated with the radium, the main substance being so-called gun cotton dissolved in alcohol, amyl acetate, ether, etc., to which must be added various other ingredients. The writer finally succeeded in obtaining a coating that provided an absolute protection to the radium film and at the same time was sufficiently thin to permit the alpha radiations and the emanations to penetrate it. This penetration of the thin coating was readily proven as follows: since the alpha radiations are readily visible to the eye when they are brought in contact with zinc sulphide, whereby they produce scintillations, as is beautifully demonstrated in the Crookes spinthariscope: the same scintillation effect took place when the coated rod or disc was placed upon the surface of a zinc sulphide screen and was observed under a fairly good magnifying glass in the usual manner.

That the emanations are able to penetrate these coatings was proven in the following manner:

A rod, properly coated and protected, was placed within a glass tube, which was fairly well closed and sealed at both ends by rubber stoppers. After this coated rod was left in the glass tube for several hours (preferably twelve to twenty-four hours) a certain quantity of emanations collected within the tube. When, therefore, an air current was slowly forced through the glass tube it carried the emanations with it, and the presence of the emanations was proven by means of an electroscope.

The method of measuring radioactive materials by an electro-

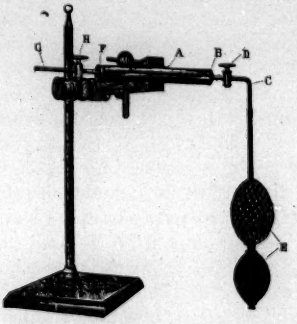
scope depends upon two well-established principles: first, that like electricity repels; secondly, that radium rays as well as radium emanations ionize the air. Ionization of the air means that the air is made a good conductor of electricity, as dry air otherwise is a non-conductor of electricity.

In the case of the Braun electroscope, an aluminum rod is suspended in a metallic case, which, for convenience, is closed off in the back and front by glass. This aluminum rod is suspended in this case by means of a piece of amber surrounded by hard rubber, both of which are non-conductors of electricity. Suspended and well balanced on this aluminum rod is an aluminum needle which moves very freely. At the lower end of the aluminum rod is an aluminum scale. When the suspended aluminum rod is charged with electricity, be it positive or negative, this electricity will instantly be conducted into the aluminum needle, and the aluminum rod and the aluminum needle will repel each other. However, only the aluminum needle can move, and will ascend the scale and will remain there until the electricity contained in the aluminum rod and the needle escapes, which escape would be extremely slow in a perfectly dry room. If we now bring radium or radium rays or emanations in the vicinity of the electroscope, these will ionize the air surrounding the electroscope and cause the electricity in the suspended rod and needle gradually to escape. The more powerful the radium is, or the larger the quantity of radiations and emanations given off, the quicker will the air be ionized, the quicker will be the discharge of electricity, and the quicker also will be the descent of the needle down the scale. By the rapidity of the descent of this needle is measured the quantity of radium or the radioactivity at our disposal.

The emanations should collect within a glass tube in which the coated rod has been contained for some time, if the writer's theory is correct that these emanations penetrate the coating. An air current blown through such a glass tube carries with it the stored-up radium emanations, and by bringing these emanations or the air charged with the emanations in contact with the electroscope the electricity contained therein always readily escapes through the ionized air and the needle of the electroscope falls more or less rapidly.

A still more efficient means of proving that the emanations penetrate the coating is by spreading the radium solution on the inside of a tube. For such purposes the writer uses preferably celluloid tubes, internally coated with a thin radium film having the same protective coating as described before. The tube is closed by means of rubber stoppers with glass stop-cocks, and all the emanations collected within this tube will follow an air current if forced through it.

In the accompanying illustration, *A* is the celluloid tube which is coated on the inside with the radium filament and protected by the protective coating. *B* and *F* are the rubber



stoppers closing off the tube at both ends. Inserted in the holes of the rubber stoppers at both ends are the glass tubes *G* and *C* with shut-off cocks *D* and *H*. These cocks remain closed when the tube is not in operation, so as to permit the gaseous emanations to collect within the tube. Then, when it is desired to utilize the emanations, the rubber bulb *E* is inflated, the glass cock *D* is opened wide and the glass cock *H* is opened very gradually. The air from *E* is forced through *C*–*D* and through the tube *A*, out through *H*–*G* and carried wherever required.

If the writer's theory is correct and the emanations can penetrate the protective coating, these emanations, as stated before, collect within the tube. Then when the air is blown through the tube it carries with it the emanations. When this so-charged air is permitted to strike the top of the electroscope, the sur-

rounding air becomes ionized and the electroscope needle descends, making it a very simple but conclusive experiment.

Thus, where formerly a glass tube containing a fairly large quantity of radium was required, which was very expensive indeed, we can obtain, by means of these coatings, the same, and even far better, results with only a small proportion of the quantity of radium formerly required. Furthermore, we have access now to all the emanations and the radiations for physiological or any other purposes desired.

The writer wants to direct attention to the following: If the beta and gamma rays, as has been asserted, are those of the greatest influence for physiological purposes or in the treatment of diseases such as cancer, lupus, etc., we must remember that these radiations are produced only by the disintegration of the radium emanation. If we now are able to take a rod or disc or any other instrument properly coated with radium and insert this into the diseased part, the emanations, whose disintegration produces these rays, will, instead of escaping into the tube and there being absorbed, now escape into the diseased part, to be retained there, to disintegrate there, and their subsequent products to produce these beta and gamma rays. Not only will these beta and gamma rays act upon the diseased part while the instrument is being applied, as was the case with the glass tube, but the radium emanation will be retained within the tissues, will continue to disintegrate, form its disintegration products, and continue to act upon these diseased parts.

An extensive series of experiments has been conducted by Prof. C. Stuart Gager, formerly of the Department of Botany, Columbia University, and now of the University of Missouri, to determine the effect of radium rays and emanations on plant life, and especially cell-formation. He has shown conclusively that in certain forms and under certain conditions radium rays, and especially the emanations emitted from a coated tube, are able to retard the growth of plants and cell-formation. Under other conditions, he very largely increased the growth as well as the cell-formation, all depending upon the various methods employed.

One important factor has to be considered in connection with these radium coatings, and that is the following: It is a well-known fact that the waters of the famous mineral springs,

especially those of Europe, have certain healing and beneficial qualities. It also has been established beyond a doubt that if these waters are transported their healing and beneficial qualities are almost entirely lost after a few days. It now has been demonstrated that all of these well-known waters and springs contain more or less radioactivity, that is, not primary radioactivity by having a radioactive material dissolved therein, but what is called secondary radioactivity, such that has been imparted to these waters by having them charged with the gas or the emanations emitted by radium. After having proven this beyond a doubt, it has been the aim of a great many of our foremost investigators to artificially produce waters which would contain emanations absorbed therein. For this purpose the celluloid tube coated on the inside with radium has been used very successfully, and it is a matter of very simple experimentation to prove the efficiency of this device and furthermore to prove the contents of radioactivity in such waters. All that is required is that the air, by means of a rubber bulb, be forced through the tube which has remained closed for several hours, and the escaping air which has been charged with emanations allowed slowly to ooze through a column of water, which should be partaken of as quickly as possible. The writer has personally seen some very remarkable and beneficial changes produced in cases of a most desperate nature.

The celluloid tube coated on the inside also has been used with great success in the treatment of throat and lung affections, the patient being required once or twice a day to inhale the air which slowly passes through the tube and which is charged with the emanations.

The writer also has succeeded in applying the radium coatings to microscopic slides. A small part of the slide is coated with the radium solution and, after evaporation of the solvent, is coated with a collodion especially prepared for this purpose. These slides have proven very efficient and of importance for biological investigations, as they can be conveniently placed under the microscope. Bacteria, cell-formation, etc., can be placed upon them, and thus the effects of the radium rays and emanations upon various microbes and cell organisms can be conveniently studied under the microscope.

In a great many cases it has been found impossible to apply

the radium either in the form of coatings or in a tube. This occurs because of the seat of the disease and the necessity of repeated treatments. In order to provide for such cases, the writer has devised what is known as radium gelatine. This is a sterilized solution of a gelatine which contains a small quantity of radium and which will coagulate when it becomes cold. However, before becoming cold, it is charged with as large a quantity of emanations as possible. This coagulated solution is heated several times, thereby liquefying it, and each time it is again charged with emanations, so that there is finally obtained a radioactive product which contains primary as well as secondary radioactivity. This gelatine is injected into the diseased parts in liquid form or is inserted by means of tampons, etc. Experience has shown that it is readily absorbed by the surrounding diseased tissues, and the radium rays, the decaying emanations, and the disintegration products are thus brought into play upon these tissues.

Steam Engines. H. HORT. (*Zeit. Ver. Deutsch Ing.*, lv. 943.)—This is a research on the properties of various volatile fluids which may be used, in conjunction with steam, in binary heat engines. The fluids mentioned are nitro-benzol, ammonia, sulphurous acid, and so on. The paper contains diagrams which illustrate the results obtained.

Babbitt Metal. C. H. CONGDON. (*The Metal Industry*, ix, 9, 393.)—The rise in the price of tin has caused a rise in the price of Babbitt metal, which contains from 80 to 90 per cent. tin, and of solder, which usually contains 40 to 50 per cent. tin. Some smelters, instead of raising the price of tin, substitute lead for more or less of the tin, ranging from 5 per cent. to 30 per cent.

Distillation of Tin in Vacuo. E. TIEDE and F. FISCHER. (*Ber.*, xliv, 1711.)—Tin was distilled in vacuo by placing a boat containing tin in a small electric furnace, which was placed within the distillation tube. This tube was made of glass, was kept cold by a stream of running water on the outside, and was connected with a vacuum pump. The first portion of the distillate had a brass-yellow color, due to the presence of sulphur. It was found possible to prepare tin from pure stannic chloride, which did not give this yellow sublimate unless it had been exposed for some time to the air of the laboratory.

A PRACTICAL APPLICATION OF FLUORESCENCE IN TESTING OILS FOR INDUSTRIAL PURPOSES.[1]

BY

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IT has been my custom, since my appointment to the Chair of Metallurgy of this Institute, to open the annual session of the section with an address on some topic allied to the art. I hope to be able to show that in speaking to you on the testing of oils I am not, as would appear, diverting from that custom, my subject having a close connection with the metallurgical art as practised in the industrial foundry.

Those of you to whom the process of casting metals is familiar know that in the operation of molding considerable attention has to be given to the production of the "core"—that part of the mold which forms the hollow portions of the casting. In cylinders for internal combustion engines, or in locomotive injectors, etc., the interior of the casting is by far the more important part, and the accuracy of reproduction of this from the mold depends, of course, mainly on the excellence of the cores used. In view of the significance of the factor, core-making is, and has always been, regarded as a distinct and separate branch of the art of molding.

Cores were formerly all made by "ramming" a mixture of sand and such adhesive materials as clay, flour, molasses-water, or other constituents into a "core-box" of suitable configuration, thereby producing a compacted mass that could be removed from the box without injury. The "green"-core, as this was termed, was transferred to an oven, where it was slowly baked until hard. In this condition it was ready for insertion in the mold.

This method of core-making is still in universal use for large work, though for smaller cores a radically different process has

[1] Abstract of address to the meeting of the Metallurgical Section, on Thursday evening, October 26th, 1911.

come into vogue. A kind of quicksand is prepared by intimately mixing, in a suitable machine, beach or bar sand (called by molders "sharp-sand") and some vegetable oil (preferably linseed oil) in the proportion of from 30 to 100 parts of sand to one part of oil. The mixture, being mobile, is poured into the core-box to well fill the latter, and the excess is simply scraped off with a straight edge drawn across the top of the box. Provision is made for taking apart the latter and leaving the fragile core on an iron plate on which it can be transported to the core-oven without injury.

These oil-cores so produced are not only far cheaper than "rammed" cores—they are made by unskilled labor in a fraction of the time taken to make rammed cores by skilled labor—but are, moreover, extraordinarily tough when baked, and are impervious to moisture. They require no "venting," as but little tendency to form gas is manifested on pouring the metal.

In consequence of these advantages, the adoption of this method of making cores has during recent years notably increased, so that, at the present time, large sums are being spent annually by industrial concerns in the purchase of oil for their production.

It was already stated that the best binder for making oil-sand cores was linseed oil. In the last few years the price of this has risen from 50 cents to $1 per gallon. "Soya" oil pressed from beans grown in enormous quantities in China has been found an excellent substitute. The cost of this is about 60 cents a gallon for fine grades. The very best substitute for linseed oil is, however, said to be crude whale oil, which costs about the same as "Soya" oil, although its use is objected to on account of the unpleasant odor emanating from the core-ovens during the operation of baking. Cottonseed oil has been used, but, as a large proportion of oil to sand is required, no economy results.

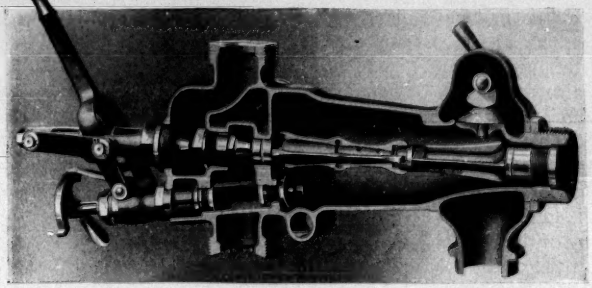
The high cost of the fine grades of these vegetable oils has brought about the introduction of so-called "core-oils." These usually consist of linseed oil as a base and mineral or resin oil, or both. Experience has shown that the presence of the latter "non-drying" oils materially affects the cores, renders them brittle and subject to rapid deterioration, and is, therefore, undesirable. Hitherto, however, no method except the costly one

of chemical analysis, usually impracticable in industrial plants, has been available for detecting their presence and amount in oils supplied.

The method about to be described to you was some months ago tried out and put into practice at the works with which I am connected. I also had the honor of demonstrating it before the American Society for Testing Materials[2] last June at Atlantic City.

The basis of the method is that hydrocarbon oils (incorrectly termed "mineral") and resin oils exhibit, under the rays of

FIG. 1.



Locomotive Injector.—Bronze casting cut to show intricate cavities and thin partition walls made with oil-sand cores.

reflected light, the phenomenon known as fluorescence and termed in this connection "bloom," while vegetable oils exhibit no such fluorescence or "bloom." All these oils appear of their natural color in transmitted light.

In both mineral and resin oils the degree or intensity of bloom depends on the degree of refinement of the oil, and is generally in proportion to its natural color. Mineral oil exhibits, however, green fluorescence, while that exhibited by resin oil is blue.

Fluorescence is the property inherent in certain substances of becoming self-luminous on exposure to "ultra-violet" or

[2] *Proceedings of the Society*, vol. xi, 1911.

"actinic" rays of light. Such rays are present to some extent in daylight, and under this the phenomenon can be observed to a certain degree.

As the result of investigation using the various forms of electric light, such as that given by carbon or tungsten filament lamps, by Cooper-Hewitt mercury vapor tubes, by ordinary and flaming arcs and by enclosed arcs, it was found that the intensity of bloom in bloom oils was particularly increased under the rays of the latter. The utilization of this observation in the practical detection of adulteration and quantity of adulteration in vegetable oils forms the subject-matter of this paper.

When it is remembered that the method of chemical analysis for the detection of a small quantity of impurity is very costly, that the method of studying fluorescence by means of quartz prisms and lenses mounted in a spectroscope has the same disadvantage, and that, moreover, skilled manipulation by highly-trained observers is essential to both, the significance of the simple method under consideration becomes at once apparent.

That the method is efficient so far as discrimination between nature of oils is concerned is shown by the fact that under the rays of the enclosed arc neither linseed oil, "Soya" oil, corn oil, cottonseed oil, China bean oil, China wood oil, nor, in fact, any of the vegetable oils, show the slightest trace of fluorescence. On the other hand, all mineral and resin oils, except the very volatile products of petroleum, such as gasolene and petroleum ether, show marked bloom, as also do samples of so-called No. 1 and No. 2 lard oils, while pure white strained lard oil is seen to be free from bloom. This latter introduces the question of oleic acid in lard oil said to be in itself fluorescent, and the method may furnish a novel means of determining the amount of such acid present.

The slight fluorescence of lard oil differs in appearance from that of mineral or resin oil, hence adulteration of lard oil by either of the latter may be detected by the method.

Processes of chemical treatment are supposed to have been discovered to "de-bloom" mineral and resin oils, thus facilitating their use as adulterants of the more expensive vegetable oils. There is at the present time a large trade in such oils.

Samples of de-bloomed oils of various grades and colors were obtained. Such exhibited no fluorescence in bright sun-

light or in the light from the ordinary arc. On exposure to the rays from the enclosed arc they are, however, seen to possess distinct bloom.

A metal-cutting compound now being sold as "mineral lard oil"—its name indicates its composition—shows strong fluorescence. Under the enclosed arc kerosene is seen to become a beautiful blue color. Cheap fuel oil from the storage tank becomes quite opaque and entirely self-luminous. Resin oils of different grades and resin oil mixed with turpentine exhibit the phenomena.

Pure linseed oil costing $1.10 a gallon, and Pennsylvania fuel oil costing 3 cents a gallon, diluted with a small quantity of kerosene, are seen to be indistinguishable under transmitted light, while under the arc the contrast between them becomes very forcible.

The demonstration shows that no misstatement is made in saying that any kind of mineral or resin oil can be distinguished from any kind of vegetable or animal oil. Further, if the latter oils be adulterated with the most minute quantity of the former the impurity can at once be detected by the method, and in many cases the nature of the adulterant can be at once stated.

The quantity of adulteration present is determined from the intensity of bloom produced in oils free from bloom; the nature of the impurity from the green or blue color.

By preparing a set of standards of pure linseed oil with one-tenth, one, two, three, four, etc., per cent. adulteration with mineral or resin oil, in glass test-tubes mounted in a suitable frame against a dark background, a means is provided whereby the proportion of impurity in any adulterated linseed oil can be quickly determined by color comparison on exposure to the enclosed arc. Such standards furnish a "scale of fluorescence" somewhat similar to the well-known carbon color-scale used in steel foundry laboratories for rapidly determining by color comparison the proportion of carbon in an acid solution of steel.

These standards, having linseed oil as a base, may be used for the examination of any adulterated vegetable oil, but for lard oil a special set of standards with pure lard oil as a base must be made up.

A set of standards was prepared with so-called bloomless mineral oil as the adulterant for the purpose of readily detecting

the presence and amount of such adulterant in any sample of vegetable oil.

Detection of the presence of a combination of mineral and resin oil adulterants in one sample of vegetable oil is rendered possible by virtue of the color of bloom imparted, although the "quantitative" determination of the amount of adulteration is at first difficult.

In cases, too, where the adulteration of vegetable oils exceeds ten per cent. it is necessary, in order to correctly estimate the exact amount of it, to dilute the sample with a known quantity of the pure oil, quantitatively determine the adulteration in this diluted oil, and thus in the original sample by calculation. This procedure is necessary from the fact that comparison of color value is impossible when the bloom is of such intensity as to produce apparent opaqueness.

In practice it has been found advisable to prepare standards with fluorescent oils of different grades as adulterants. Crude mineral or resin oils are much darker in natural color than refined oils from them, and the color of the oil by transmitted light is often a guide to the nature of the adulterant employed, and consequently furnishes an indication of the proper set of standards necessary in making the "quantitative analysis" by comparison of fluorescence.

In conclusion, this practical application of fluorescence to the testing of oils for industrial purposes is not, of course, intended to furnish a method to supplant chemical analysis, but merely to afford a means of rapidly ascertaining whether an expensive vegetable or animal oil is or is not free from suspicion of adulteration. At the same time, however, the method is so sensitive in the case of mineral oil adulterants most commonly used as to furnish a correct indication of the amount of adulterant present. The fluorescent tint here exhibited is one so characteristic that after a little practice it cannot be confused with the slight fluorescence of some oils in which no mineral oil is present.

The fluorescent test for kerosene adulterant is, however, not sufficiently sensitive to be of practical value, for the reason that kerosene is not of itself fluorescent enough to tinge other oils to which it is added in small amounts.

In presenting this new method of testing oils without the necessity of chemical knowledge or experience criticism is invited, for only by such can any faults that may have been overlooked be developed, or any advantageous features that may have escaped observation be brought out.

COMMUNICATED DISCUSSION.

MR. NEMZEK: I have listened with considerable interest to the excellent address made by Mr. Outerbridge, and feel the same as I did last June at Atlantic City when I had occasion to hear this talk given before the American Society for Testing Materials; namely, that it is a valuable addition to the analysts' methods for the examination of oils.

Since I first heard the talk and witnessed the demonstrations that you have just seen I installed an enclosed arc lamp and made some experiments in an attempt to establish the value of the method for quantitative purposes. If it proved accurate it would be a boon for my laboratories. I found that the fluorescence or "bloom" is greatly magnified, but apparently the value of the method was limited to this fact. The great number of resin and mineral oils makes impossible accurate quantitative results. The range of color in the samples showing fluorescence varied from a light blue through the purples and extended into dark greens. It would be necessary to have a set of standards made up from each kind of oil on the market, and, in a specific case, inside information as to the nature of oil used for adulteration. Unless this was available, any consistency regarding quantitative results is impossible.

In making up tests for quantitative analysis by using different kinds of mineral oils it was possible in one case to obtain what appeared to be a two per cent. adulteration, when in reality thirty per cent. of a mineral oil was present. In another instance a thirty per cent. adulteration with a so-called de-bloomed oil showed only two per cent. by this test. This merely illustrates the wide variation in bloom created by different mineral oils.

Furthermore, about fifteen per cent. of the samples of pure linseed oil examined showed marked fluorescence; about 70 per cent. of boiled linseed oils showed a characteristic bloom;

several samples of spirits of turpentine gave affirmative results, and 60 per cent. of wood turpentine samples gave marked color reactions.

These reactions are easily explained in the case of the turpentines, but no real reason is found in the case of the linseed oils. The analysis showed them to be pure. The one possibility is that a drop or two of mineral oil from machinery used in the manufacture of the oil has contaminated it. This is a remote instance, but if true would indicate that the method will not meet practical application, as it would prove misleading.

From the above it can readily be seen that this test in the hands of an experienced operator would prove dangerous and lead to serious complications.

There has come to my attention information which indicates that one of the Government laboratories has lately issued a bulletin on the subject of tests for fluorescence of mineral and resin oils, which substantiates in substance some of the remarks I have made.

As a matter of information I might say that we have no trouble in obtaining pure linseed oils. If adulteration exists it is not so much present in the form of mineral or resin oils, but rather some semi-drying oils the character and percentage of which it is a difficult thing to determine, even by chemical analysis.

I do not desire to detract from the very valuable contribution to science that Mr. Outerbridge has given us by his interesting discourse, and I merely state these facts to bring to your minds some features in connection with the method that may prove of help to you, and incidentally show the necessity of carefulness in exploiting a new test of this kind.

PROFESSOR OUTERBRIDGE: I have already said that I welcome the fullest discussion and criticism of this novel method of detecting the presence of mineral and resin oils in other oils, and I am pleased to note that the gentleman who has just spoken regards this process as "a valuable addition to the analysts' methods for examination of oils."

I, myself, have only ventured to regard it as a *substitute* for analysts' methods in cases where such slow and tedious processes are not available or practicable in foundries and workshops.

Mr. Nemzek says "in making up tests for quantitative analysis by using different kinds of mineral oils it was possible in one case to obtain what appeared to be a two per cent. adulteration, when in reality thirty per cent. of a mineral oil was present." He doubtless refers to kerosene as the adulterant in this case. Had he used thirty per cent. of gasolene or petroleum ether he would have found no fluorescence imparted to the linseed oil, for the highly volatile products of petroleum are not fluorescent.

Kerosene when added even in very small quantity to other oils is readily detected by its odor, and if added in considerable amount renders the mixture extremely limpid and suspiciously light in color. I do not regard kerosene as a dangerous adulterant for these reasons.

Mr. Nemzek says "in another instance a thirty per cent. adulteration with a so-called de-bloomed oil showed only two per cent. by this test." The comparison is evidently made with a sample containing two per cent. of highly fluorescent mineral oil, not de-bloomed.

A casual inspection by transmitted light would prevent such a palpable error, as I have already explained. Furthermore, there is an appreciable difference between the fluorescent tints of de-bloomed oil and ordinary mineral oil. Finally, I may say that I have boiled several samples of pure non-fluorescent linseed oil until they became quite dark in color and have not observed the development of fluorescent tints that could be mistaken for the characteristic bloom of mineral oil when examined under the rays of an enclosed arc lamp.

I fully agree with Mr. Nemzek's concluding remarks and was careful, "in exploiting a new test of this kind," to state that it must not be expected that it will supplant chemical analysis of oils in laboratories, but that it will serve as a rapid substitute for analysis in detecting the presence of mineral and resin oil adulterants in other oils where chemical analysis is not available. I said in my original presentation of the process that "I ventured to hope that it might even prove of assistance in chemical laboratories." Mr. Nemzek's first statement seems to more than confirm this anticipation.

Resistance of Ingrain Colors against Re-solution. W. P. DREAPER and A. WILSON. (*J. Soc. Dyers and Col.*, xxvii, 170)—In order to determine the influence of the temperature of dyeing of ingrain colors on the fastness of the shades obtained, samples of silk were dyed to the same shade with the pure sodium salt of the sulphonic acid of Primuline base at 100° C and 15° C. The dyed samples were then diazotized, developed with β-napthol, and subjected to the action of a 1 per cent. sodium oleate solution at 95° C. for one hour. The sample dyed at 15° C. lost 67 per cent. of color by re-solution, that dyed at 100° C lost only 17 per cent. When R salt was used as the developer, the loss of color after 10 minutes' soaping at 95° C. was 12 per cent. on the sample dyed at 100° C. and 94 per cent. on that dyed at 15° C. Samples dyed at 100° C. and 15° C. were developed with β-napthylamine, and after soaping lost 4 per cent. and 95 per cent. respectively. Similar, but less marked, results were obtained on dyeing cotton instead of silk.

Chromium Steels. PORTEVIN. (*Comptes Rendus*, cliii, 64.)—Guillet found that chrome steels with 0.1 per cent. of carbon and 7 to 22 per cent. of chromium were martensitic. Portevin shows that in this state they are not really stable, and that by extremely slow cooling from 1300°C. they can be brought into a state similar, in structure and hardness, to that of ordinary steels of the same carbon contents. If in this condition they are subjected to annealing in the ordinary, practical acceptation of the term, the effect is that of quenching; they become martensitic and increase considerably in hardness.

Wattmeter Errors at High Frequencies. E. BEHNE. (*Elektrotechnik u. Maschinenbau*, xxix, 257.)—The effect of the mutual induction between the fixed and movable coils of a wattmeter and the self-induction of the latter coils on the readings of the instrument was investigated. A number of calculations at 500 cycles per second were made, and it was shown that errors can be eliminated by putting a condenser in the moving-coil circuit. This was demonstrated by experiment.

Metallic Oxides as Arc Light Electrodes. B. MONASCH. (*Jour. Gasbel.*, liii, 1122.)—In endeavoring to discover some oxide, or mixture of oxides, for electrodes, that would be of greater efficiency than those now in use, it was found that the oxides of titanium, vanadium, yttrium, crium, uranium and tungsten were the most suitable; titanium oxide being the most efficient. Titanium oxide is more efficient than magnetite, and the more titanium oxide that is added to the magnetite, the more the efficiency of the electrode is increased, until the maximum is attained with pure titanium oxide.

FRANKLIN INSTITUTE.

(*Proceedings of the Stated Meeting held Wednesday, November 15, 1911.*)

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, November 15, 1911.

DR. GEORGE A. HOADLEY, *Temporary Chairman.*

Additions to membership since last report, 21.

The resolution from the Board of Managers recommending Professor Charles F. Chandler, Emeritus Professor of Chemistry, Columbia University, New York, N. Y., for honorary membership was adopted.

The paper of the evening was presented by Professor Cleveland Abbe, Ph.D., LL.D., of the U. S. Weather Bureau, Washington, D. C., on "Obstacles to the Progress of Meteorology."

Dr. Abbe spoke of the present impossibility of making long-range weather predictions on account of the limited data in the hands of the climatologist on the fundamental laws of radiation and of motion of gases.

He advocated the establishment of laboratories equipped for the experimental study of atmospherics for the benefit of meteorologists

At the close of the paper the thanks of the meeting were extended to Dr. Abbe.

Adjourned.

R. B. OWENS,
Secretary.

COMMITTEE ON SCIENCE AND THE ARTS.

(*Abstract of Proceedings of the Stated Meeting held Wednesday, November 1, 1911, and the Adjourned Meeting, November 8, 1911.*)

DR. GEORGE A. HOADLEY *in the Chair at both Meetings.*

The following protests were considered:

No. 2489.—Hopkins Speedometer and Dynamometer. Sub-committee reappointed.

No. 2501.—Wolf's Liquid Gas. To be reconsidered by general committee.

The following report was presented for final action:

No. 2477.—Granbery's Stadia Rod. Advisory. Adopted.

The following report was presented for first reading:

No. 2499.—Santo Vacuum Cleaner. Reported progress.

R. B. OWENS,
Secretary.

SECTIONS.

Mining and Metallurgical Section.—A meeting of the Section was held on Thursday evening, October 26, 1911, at 8 o'clock.

The meeting was called to order by the president of the Section, Prof. A. E. Outerbridge, Jr. Sixty members and visitors were present. Professor Outerbridge presented his annual address as president of the Section on "A Practical Application of Fluorescence in Testing Oils for Industrial Purposes." (An abstract of the paper is printed in this issue.)

In connection with his remarks Professor Outerbridge gave a demonstration of his method of detecting mineral and resin oil impurities in vegetable oils, particularly in linseed oil used in making oil-sand cores. He also exhibited samples of such cores made with pure and with adulterated oil, as well as intricate castings illustrating the importance of the art of core-making.

After discussion, the thanks of the meeting were extended to the speaker.

Adjourned.

R. B. OWENS,
Secretary.

Section of Physics and Chemistry.—By invitation of the Faculty of Pharmaceutic Chemistry of the Medico-Chirurgical College of Philadelphia, a meeting of the Section was held in the Chemical Lecture Hall of the College on Thursday, November 9, 1911, 8 P.M., with Prof. Carl Hering in the chair. Fifty-two members and visitors were present. The minutes of the previous meeting were read and approved. Prof. George H. Meeker, Ph.D., Dean of the Faculty of Pharmaceutic Chemistry of the Medico-Chirurgical College, presented a communication on "Some Electro-Chemical Experiments." The various experiments which show the migration of ions during the passage of an electric current through a solution, and which are described in the literature, were enumerated. Dr. Meeker then described a new experiment which demonstrates the migration of the ions, and also described and carried out certain experiments devised by himself which bear on the relation between the passage of the current and the migration of the ions. The paper was discussed by Doctors Goldsmith, Hillebrand, and Meeker, and by Professor Hering.

A vote of thanks was extended to Dr. Meeker, and the meeting adjourned to inspect the laboratories and apparatus of the college.

JOSEPH S. HEPBURN,
Secretary.

SURFACE COMBUSTION AND ITS INDUSTRIAL APPLICATIONS.

A communication on the above subject was presented to a large audience in the hall of the Institute on the evening of Monday, October 30, 1911, by Prof. W. A. Bone, D.Sc., Ph.D., F.R.S., Professor of Applied Chemistry, University of Leeds, England.

The speaker was introduced by President Walton Clark, and described his newly-discovered method for the production of high temperatures and its applications in the industries.

A large amount of apparatus was installed and numerous experiments shown illustrating the subject of his paper.

A full text will be printed in a future issue of the JOURNAL.

MEMBERSHIP NOTES.

Elections to Membership.

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MR. JOHN J. BURLEIGH, Merchantville, N. J.
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MR. G. C. VOGEL, 409 Terrace Ave., Milwaukee, Wis.
MR. O. L. WEST, Bourse Building, Philadelphia, Pa.
MR. B. C. WOLVERTON, 207 State St., Syracuse, N. Y.

NECROLOGY.

Rev. Henry Christopher McCook, D.D., Sc.D., LL.D., Presbyterian clergyman, author and entomologist, honorary member of the Institute, died at his home in Devon on October 31st.

Dr. McCook was born in New Lisbon, O., July 3, 1837. In early boyhood he was a printer's apprentice. Later, changing his views, he determined to study the law, but finally decided to enter the ministry. He graduated from Jefferson College, at Canonsburg, now Washington and Jefferson College at Washington, in 1859, and took up his further course at the Western Theological Seminary, Allegheny.

Dr. McCook was known throughout the country not only for his prominence as a clergyman, but perhaps even more widely for his achievements in the science of entomology. His works on ants and spiders are especially valuable, and he was recognized as an authority on these insects.

Dr. McCook's first active work in the ministry was as chaplain of the 41st Illinois Volunteers in 1861–62. He always maintained his interest in military organizations, and was Chaplain of the Pennsylvania Commandery of the Loyal Legion and of the Second Regiment. He was also the founder of the National Relief Commission in the Spanish-American War. He was president of the American Entomological Society, vice-president of the Academy of Natural Sciences and president of the American Presbyterian Historical Society.

Dr. McCook's work in church heraldry has placed his name foremost in this line. He designed the seal of the Presbyterian Church in this country, adopted in 1892 by the General Assembly. He was an honorary member of the British Association for the Advancement of Science, and was one of the managers of the Wistar Institute and a trustee of the Presbyterian Hospital.

Dr. McCook's publications have been voluminous. They include "Agricultural Ants of Texas," "Honey and Occident Ants," "American Spiders and their Spinning Work" (a work in three volumes), "Tenants of an Old Farm," and "Old Farm Fairies." All of these are scientific works. Other works by Dr. McCook are: "Ecclesiastical Emblems," "The Latimers" (A Scotch-Irish historical romance), "Martial Graves of our Fallen Heroes in Santiago de Cuba—A record of the Spanish-American War," and "The Senator—A Threnody in Verse and Prose."

Miss Mary R. Burton
Mr. Henry J. Crump
Mr. Jarvis B. Edson
Mr. Howard Wood

LIBRARY NOTES.

Purchases.

International Catalogue of Scientific Literature. B. Mechanics. Ninth annual issue.

International Catalogue of Scientific Literature. E. Astronomy. Ninth annual issue.

International Catalogue of Scientific Literature. J. Geography. Ninth annual issue.

SEIDELL, A.—Solubilities of Inorganic and Organic Substances.

MEYER, R.—Jahrbuch der Chemie.

DUNCAN, J. C.—Principles of Industrial Management.

BROOKS, J. P.—Reinforced Concrete.

ABBOT, C. G.—The Sun.

REDMAYNE, R. A. S.—Modern Practice in Mining. 3 volumes.

BARTHOLOMEW, J. G.—Cassell's Atlas.

DUNCAN, R. K.—Some Chemical Problems of To-day.

CARDULLO, F. E.—Practical Thermodynamics.

MOYER, J. A.—Power-plant Testing.

United States Patent Office.—Manual of Classification of the German Patent Office.

RUDZKI, M. P.—Physik der Erde.

STARKE, H.—Experimentelle Elektrizitätslehre.

HOWE, G.—Mathematics for the Practical Man.

GANTT, H. L.—Work, Wages, and Profits.

BORCHERS, W.—Electric Furnaces.

BAEDEKER, K.—Die elektrischen Erscheinungen in metallischen Leitern.

TAYLOR, F. W.—The Principles of Scientific Management.

KERSHAW, JOHN B. C.—The Electric Furnace in Iron and Steel Production.

Annual Library Index. 1910.

Iron and Steel Institute Journal. Index vols. 59-82.

NAGEL, O.—The Lay-out, Design, and Construction of Chemical and Metallurgical Plants.

WOOD, R. W.—Physical Optics. Second edition.
FLEMING, J. A.—The Propagation of Electric Currents.
EVANS, J. C.—Physico-chemical Tables. 2 volumes.

Gifts.

New South Wales. Annual Report of the Department of Mines for the year 1910. Sydney, 1911. (From the Department.)

Amsterdam Academy of Science. Proceedings of the Section of Sciences. Vol. 13, parts 1 and 2. Amsterdam, 1910-1911. (From the Academy.)

Amsterdam Academy of Science, Year-Book 1910. Amsterdam, 1911. (From the Academy.)

Vermont Insurance Commissioners. Report for year ending December, 1910. Concord, 1911. (From the State Library.)

New York State Museum. Report for 1909. Vols. 1–5. Albany, 1911. (From the State Library.)

San Fernando. Instituto y Observatorio de Marina. Almanaque Nautico, 1913. San Fernando, 1911. (From the Observatory.)

Canada Year-Book 1910. Ottawa, 1911. (From the Census and Statistics Office.)

Antikvarisk Tidskrift for Sverige, No. 19, Utgifven af Kungl. Vitterhets Historie och Antikvitets Akademien. Stockholm, 1911. (From the Academy.)

Hamilton Association, Journal and Proceedings. Nos. 25 and 26. Sessions 1908-09 and 1909-10. Hamilton, 1910. (From the Association.)

Illinois Bureau of Labor Statistics. Bulletin. Labor legislation enacted by the 47th General Assembly, 1911. Springfied, 1911. (From the Bureau.)

Pennsylvania Topographic and Geologic Survey Commission Report, 1908–1910. Harrisburg, 1911. (From Mr. E. V. d'Invilliers.)

New South Wales Official Year-Book, 1909-10. Sydney, 1911. (From the Bureau of Statistics.)

Philadelphia Bureau of Water, 109th annual report, for the year 1910. Philadelphia, 1911. (From the Bureau.)

Alabama Geological Survey. Bulletin No. 10. Reconnoissance Report on the Fayette Gas Field. Bulletin No. 11, Roads and Road Materials of Alabama. Montgomery, 1911. (From the Survey.)

Ohio State Mining Department, 36th annual report of the Chief Inspector, for 1910. Columbus, 1911. (From the Department.)

BOOK NOTICES.

CARNEGIE INSTITUTION OF WASHINGTON PUBLICATIONS:

No. 119. PERRINE, CHARLES D. Determination of the Solar Parallax from Photographs of Eros made with the Crossley Reflector of the Lick Observatory. Quarto, v+98 pages, 1 plate, 2 text figures. Published 1911. Price, $2.50.

This publication gives a detailed account of observations and computations made in deriving the solar parallax from photographs of the minor

planet Eros taken by means of the Crossley reflecting telescope of the Lick Observatory during the interval October, 1900, to January, 1901. The value of the parallax deduced is $8.8067' \pm .0025''$.

No. 138. ADAMS, WALTER S., assisted by JENNIE B. LASBY. An Investigation of the Rotation Period of the Sun by Spectroscopic Methods. Quarto, III+132 pages, 2 plates, 5 text figures. Published 1911. Price, $3.

The results of a determination of the rotation period of the sun from the displacements of the spectrum lines. The material employed consists of two series of photographs obtained at the Mount Wilson Solar Observatory during the years 1906-7 and 1908 with fixed spectrographs of high dispersive power. The methods of observation and reduction are discussed in full, and a comparison is made with the results of other observers and with the values of the rotation period as derived from studies of sun-spots, faculæ and flocculi.

Special series of observations with lines of hydrogen and calcium indicate a more rapid period of rotation for the gases of these elements as well as a modification of the law of the equatorial acceleration. Similar results to a less degree are found for certain of the weaker lines of the reversing layer.

No. 147. RUSSELL, HENRY NORRIS. Determinations of Stellar Parallax, based upon Photographs taken at the Cambridge Observatory by Arthur R. Hinks and the writer; with Magnitudes and Spectra determined at the Harvard College Observatory under the direction of Prof. E. C. Pickering. Quarto, VI+142 pages. Published 1911. Price, $2.

This work is based on 254 plates and 37 different fields, taken with the Sheepshanks *equatoréal coudé* of 12 inches aperture and 20 feet focal length. The relative parallaxes of 52 stars especially selected for observation, and of 242 others chosen as objects of comparison, have been determined. Every precaution was taken to eliminate systematic error; and the discussion of the results for the comparison-stars indicates that the residual errors—whether depending on a star's position, magnitude, or spectral type, or on the season of the year at which observations were made—cannot exceed a few thousandths of a second of arc. As regards accidental errors, the results appear also to be of high precision. The conditions suitable for obtaining the most accurate results for a given amount of work expended are next discussed, and later the astrophysical conclusions derivable from the data for the principal stars. Detailed tables of the numerical results of observation conclude the volume.

No. 149. BARUS, CARL. The Production of Elliptic Interferences in Relation to Interferometry. Octavo, VI+77 pages, 33 text figures. Published 1911. Price, $1.25.

In the cases of coronas there is a marked interference phenomenon superposed on the diffractions. This suggested the present investigation, which aims at a simplification of the effect in question by bringing two

complete component diffraction spectra, from the same source of light, to interfere. Many ways are shown to be available, the methods being either direct (as discussed in Chapters II and III, where a plane mirror immediately behind the grating returns reflected-diffracted and diffracted-reflected rays) or indirect, using the devices of Jamin, Michelson, and others (Chapters IV and V). In Chapter I a modification of Rowland's apparatus, suitable for plate gratings, is described. The direct method gives equidistant fringes, duplex in character, but rigorously straight throughout the spectrum, their distances apart and inclinations being measurable by ocular micrometry. Lengths and small angles are thus subject to micrometric measurement. In case of the indirect method, the half-silvered plate is replaced by the grating; the fringes are, as a rule, approximately elliptic (confocal) throughout the spectrum, and the fringes again partake of both a drift and radial motion, when the interferometer adjustment is altered. Drift and radial motion may be regulated in any ratio. The theory of the subject is worked out, in so far as it bears on the practical results obtained.

A SYSTEMATIC HANDBOOK OF VOLUMETRIC ANALYSIS. By Francis Sutton. Tenth edition by W. L. Sutton and A. E. Johnson. Philadelphia: P. Blakiston's Son & Co.

"Sutton" is the standard work on Volumetric Analysis, and while other excellent works on this subject have been published in the English language during the period of forty years since the appearance of the first edition, the present thoroughly-revised and much improved edition may fairly claim a place upon the book-shelves of every analyst as the most comprehensive and up-to-date treatise on the subject.

In comparing this tenth edition with the preceding ones, we cannot help being very favorably impressed with many new features and conspicuous improvements of the text. Thus the sections on the instruments of precision employed in volumetric analysis have been entirely rewritten with the assistance of R. J. Glazebrook, of the National Physical Laboratory. The term "normal solution" is more exactly defined, and the section on Indicators materially amplified. Many obsolete processes have been eliminated, and a considerable number of new methods introduced. Among the latter we note especially those under "Ammoniacal Liquors," "Ferrocyanides," "Acetone," "Oils, Fats, and Waxes," and many of the metals. A decided improvement, too, has been effected in carrying all the references in the text to the foot of the page.

In spite of the many changes, the size of the book has been only very slightly increased, and the editors deserve much praise for having accomplished this without altering the scope and character of this standard work.

H. F. KELLER.

WOLFRAM: eine Monographie. By Heinrich Leiser, Ph.D. Pp. 222. Halle a. S.: Wilhelm Knapp. Price, paper, 12 marks.

Although tungsten was discovered 130 years ago, it is only two decades since this metal has found extended industrial applications. In view of these, and particularly the uses of tungsten in the manufacture of incan-

descent electric lamps and of special steels, the publication of a monograph, such as this, must be hailed as a most welcome addition to the literature of industrial chemistry.

Following a brief historical sketch of the element, the book contains a very complete account of our present knowledge of it, under the headings: 1. Occurrence of the tungsten ores; 2. The manufacture of the tungsten salts and the metal; 3. The chemistry of tungsten and analysis of the tungsten products; 4. The physical and physiological properties of tungsten; 5. Industrial applications: the tungsten lamp and the high-speed steels; 6. The alloys of tungsten; 7. Other uses of tungsten and tungsten products; and an appendix on the patent claims relating to the tungsten lamp.

While we miss in this book a number of contributions made to the chemistry and applications of tungsten by American investigators and inventors, it presents the subject in a well-arranged and usable form, and contains a wealth of valuable information not readily to be found elsewhere. It is printed in clear type on good paper.

H. F. KELLER.

TRAITÉ DE RADIOACTIVITÉ. Par Madame P. Curie. In 2 volumes. Paris: Gauthier-Villars, 1910.

It would be difficult to instance in the history of science a parallel to the rise and development on that new and flourishing branch of physical science which is called radioactivity. Only fifteen years have elapsed since the late Henri Becquerel made the great and fundamental discovery of the peculiar radiations emitted by uranium, and to-day our knowledge of such radiations and their sources, acquired by means of physical and chemical methods in the hands of some of the most distinguished investigators of our time, constitutes an independent science whose extended border-line is drawn with peculiar sharpness.

Among those who have actively contributed to these vast new stores of knowledge no one stands out more conspicuously, in respect to both the extent and importance of his or her discoveries, than the author of this latest and most authoritative treatise on the subject. Shortly after Becquerel's fundamental discovery Mme. Curie succeeded in tracing the uranium rays to their source, demonstrating that they are an atomic property of uranium, and in isolating from uranium ore new and vastly more radioactive substances—polonium and radium. In part of these investigations, as well as in many that followed, she enjoyed the coöperation of her husband, Prof. Pierre Curie, whose lamented death occurred in 1906. Since that time she has uninterruptedly continued her beautiful researches in the field in which she and her husband will ever be recognized as the pioneers.

Mme. Curie was also the first writer who gave a connected and satisfactory account of the early work done in radioactivity. She published it as a thesis for the Doctorate in 1903, under the title, "*Les Substances Radioactives.*" Since then a great number of books on the subject have been written in many languages, the best one, undoubtedly, by Prof. Ernest Rutherford. This excellent work, which has passed through several editions and has been translated into other languages, served as the chief work of refer-

ence on radioactivity for the past five years. The phenomenal strides, however, by which the new science has been advancing in recent years have created a demand for a still larger and more complete treatise on the subject, and the present work was written to meet this want.

As Mme. Curie tells us in the preface, the book is founded upon a course of lectures she delivered at the Sorbonne as professor of the *Faculté des Sciences*. It is, therefore, addressed to the special student of the subject rather than to the general reader.

It will suffice here to indicate in a general way the contents of the several chapters, and to add a few remarks on the character of this new standard work.

Volume I begins with a discussion of Ions and Electrons, which is followed by chapters under the following captions: Methods of detecting and measuring radioactivity; radioactivity of uranium and thorium, radioactive minerals; the new radioactive substances; transient radioactivity; radioactive gases, or emanations; induced radioactivity; the theory of radioactive transformations.

Volume II is devoted to an exhaustive discussion of the nature of the radiations; the phenomena occurring in the presence of the radioactive substances; the description of the several "families" of radioactive elements; the genesis and relations of these elements; and it concludes with a chapter on the radioactivity of the sun and of the atmosphere.

The presentation of the subject is inductive rather than historical. The development is admirably logical and reveals the author's masterly command both of the methods and the literature of all that pertains to radioactivity. Full recognition is accorded to the labors of other investigators, and no undue prominence is given to the researches of the author and her associates. A careful examination of the text discloses the painstaking care with which it was prepared for the press, and that it is remarkably free from typographical errors. The typography, indeed, is most excellent, as is also the paper. The illustrations are clear and appropriate. A fine portrait of Pierre Curie adorns this work as the frontispiece: a tender and fitting tribute to his memory.

H. F. KELLER.

PUBLICATIONS RECEIVED.

A Short Course in the Testing of Electrical Machinery for Non-electrical Students. By J. H. Morecroft and F. W. Hehre. 154 pages, illustrated, 8vo. New York, Van Nostrand Co., 1911. Price, cloth, $1.50 net.

Allen's Commercial Organic Analysis: A Treatise on the Properties, Modes of Assaying, and Proximate Analytical Examination of the Various Organic Chemicals and Products. . . . Volume 5. Tannins, analysis of leather, dyes and colouring matters, dyestuffs of groups 6 to 12, colouring matters of natural origin, analysis of colouring matters, colouring matters in foods, inks. . . . Fourth edition, entirely rewritten. 704 pages, 8vo. Philadelphia, P. Blakiston's Son & Co., 1911. Price, cloth, $5 net.

U. S. Bureau of Mines. Miners' Circular 5. Electrical Accidents in Mines: Their Causes and Prevention. By H. H. Clark, W. D. Roberts, L. C. Ilsley, and H. F. Randolph. 10 pages, illustrations, 8vo. Washington, Government Printing Office, 1911.

U. S. Coast and Geodetic Survey. Results of Observations made at the Coast and Geodetic Survey Magnetic Observatory at Baldwin, Kans., 1907–1909, by Daniel L. Hazard, Computer, Division of Terrestrial Magnetism. 114 pages, plates, 4to. Washington, Government Printing Office, 1911.

U. S. Bureau of Mines. Bulletin No. 13, Résumé of Producer-gas Investigations, October 1, 1904, to June 30, 1910. By R. H. Fernald and C. D. Smith. 393 pages, illustrations, plates, tables, 8vo. Washington, Government Printing Office, 1911.

U. S. Department of Agriculture, Office of Public Roads. Circular No. 96, Naphthaline in Road Tars. 1. The Effect of Naphthalene upon the Consistency of Refined Tars. By Prevost Hubbard, chemist, and Clifton N. Draper, assistant chemist. 12 pages, 8vo. Washington, Government Printing Office, 1911.

Pennsylvania Topographic and Geologic Survey, Report 1908–1910. 103 pages, illustrations, plates, maps, 8vo. Harrisburg, State Printer, 1911.

U. S. Department of Agriculture, Forest Service. Circular No. 187. Manufacture and Utilization of Hickory, 1911. By Charles F. Hatch, Statistician in Forest Products. 16 pages, 8vo. Washington, Government, 1911.

Di-el-lite Resistance Units (Resistors). Descriptive pamphlet. 12 pages, illustrations, 8vo. Philadelphia, Wirt Electric Specialty Co., 1911.

Rensselaer Polytechnic Institute. Engineering and Science Series No. 1, Metallic Titanium. By Matthew A. Hunter. 12 pages, illustrations, 8vo. Troy, N. Y., Institute, 1911.

U. S. Bureau of Mines. Bulletin 19, Physical and Chemical Properties of the Petroleums of the San Joaquin Valley of California. By Irving C. Allen and W. A. Jacobs. With a chapter on natural gas from the oil fields of Southern California by G. A. Burrell. 60 pages, plates, 8vo. Washington, Government, 1911.

U. S. Coast and Geodetic Survey. Results of Observations made at the Coast and Geodetic Survey Magnetic Observatory at Vieques, Porto Rico, 1907 and 1908, by Daniel L. Hazard, Computer, Division of Terrestrial Magnetism. 98 pages, plates, 4to. Washington, Government, 1911.

Royal Institution of Great Britain. Weekly evening meeting. March 10, 1911—Recent Advances in Turbines, the Hon. Sir Charles A. Parsons. March 31, 1911—Travelling at High Speeds on the Surface of the Earth and Above it, Prof. H. S. Hele-Shaw. May 5, 1911—New Organic Compounds of Nitrogen, Prof. Martin O. Forster. May 12, 1911—Biology and the Cinematograph, Prof. William Sterling. June 2, 1911—Radiotelegraphy, Commendatore, G. Marconi. 5 pamphlets, illustrations, plates, 8vo. London, Institution, n. d.

CURRENT TOPICS.

"New Data on Some Electrical Properties of Sodium, Potassium, and Their Alloy."—Under the above title Dr. Edwin F. Northrup, of the Palmer Physical Laboratory, Princeton University, presented to the American Electrochemical Society the results of an investigation, of which the following is an abstract:

A glass tube with platinum potential and current terminals was first filled with pure mercury and the resistance of this was determined between the potential points in the temperature range 21.48° to 106.8° C. The same tube was then filled with molten sodium and the resistance of this determined in the range of temperature 21.4° to 141.2° C. The same was done for potassium in the range 21.2° to 63.2° C., and for an alloy of equal parts by volume of sodium and potassium in the range 2.8° C. to 131.2° C.

Using the known constants for mercury, the temperature coefficients and the specific resistances of the sodium, potassium, and the alloy were deduced from the observed data. A summary of the results deduced is given in the table below. Other facts of interest brought out are the following:

Substance	Spec. Res. at 20° C. $10^{-9}\,\Omega$	Spec. Res. at 100° $10^{-9}\,\Omega$	Temp. Coef. Low Range	Temp. Coef. High Range	Density at 0°
Mercury	95782	103560	0.001003 (20° to 100°)	. . . . .	13.595
Sodium	4873	9724	0.0053 + (20° to 80°)	0.00494 + (100° to 140°)	0.978
Potassium . . .	7116	15306	0.0058 (20° to 50°)	0.00507 + (66° to 120°)	0.87
Alloy, K+Na .	33792	37872	. . . . .	0.00147 (46° to 125°)	0.92
Copper	1721	2266	0.00387 +	. . . . .	8.89

Sodium in passing from the solid state at 93.5° C. to the liquid state at 96.3° C. experiences an abrupt increase in resistance of 44.8 per cent.; potassium in passing from the solid state at 60.4° C. to the liquid state at 63.2° C. increased 52.2 per cent.; and the alloy, equal parts by volume in passing from 2.8° C., at which temperature it is completely solid, to 20° C., at which temperature it is completely liquid, increased 48.5 per cent. The temperature coefficient of potassium in the range of 20° to 50° is 0.0058, and of sodium in the range of 20° to 80° is 0.0053. The coefficient of the alloy of potassium and sodium, instead of being the mean of the coefficients of sodium and potassium when liquid, is only between a third and a

fourth of the mean value of the coefficients of its constituents in the same temperature range.

The mean specific resistance at 100° C. of sodium and potassium is but about one-third the mean specific resistance of the alloy of these two metals in equal proportions by volume at the same temperature.

The ratio of the resistivity at 20° C. of sodium to copper is 3.058, but the density of copper is almost exactly nine times that of sodium, which in round numbers makes sodium three times as good a conductor per unit of weight as copper. Hence it could compete with copper as a conveyor of electric power if it cost anything less than three times as much as copper per pound, provided current carrying capacity were the only consideration. Sodium has been quoted at $0.25 a pound. If confined in iron pipes it might be an economical conveyor of electric energy over short distances for the enormous currents used in electrochemical processes.

Sulphur Production an American Industry. (*United States Geological Survey Report.*)—The United States produced 255,534 long tons of sulphur in 1910, valued at $4,605,112, according to figures compiled by W. C. Phalen, of the United States Geological Survey, and just published as an advance chapter from "Mineral Resources." This is an increase of 16,222 tons in quantity and $173,046 in value over the output for 1909.

The sulphur industry in this country is substantially an American one, for the imports for 1910 were valued at only $558,611, while the exports amounted to $552,941. Four States—Louisiana, Nevada, Utah, and Wyoming—produced practically all of our sulphur. Mr. Phalen discussed the geological occurrence and technology of sulphur in the 1909 chapter of "Mineral Resources." In the chapter for 1910 he gives a detailed account of the important foreign sulphur deposits—those of Italy, Japan, and other countries.

The report also contains the statistics of production of pyrite in the United States, which in 1910 amounted to 238,154 long tons, valued at $958,608. The imports of this mineral were largely in excess of the domestic production, being 803,551 long tons in 1910, valued at $2,748,647. A copy of the report can be had on application to the Director of the United States Geological Survey, Washington, D. C.

The Genealogy of Some Radio-active Bodies. ANON. (*Cosmos*, No. 1369, 423.)—The radio-active chemical elements are transmuted from one to another either by evolution or by descent. Although it is customary to specially distinguish only a small number of these elements, such as uranium, thorium, and radium, it must not be overlooked that a great variety of intermediary radio-active elements exist, which owe their existence to those which have a more or less long life. For instance, let us consider the

genealogical tree of *thorium*. This radio-active metal first disintegrates, transforming itself into *meso-thorium I*, which has a middle life of 8 years (that is to say, a given mass of meso-thorium I is reduced to one-half at the end of 8 years) and then changes into *meso-thorium* II, which in its turn wears out in 9 hours, with the emission of β rays (negative electrons) and γ rays (analogous to X rays), becoming radio-thorium. Each atom of radio-thorium expels an α particle (a positive particle of electricity, which is known to be identical with an atom of electrified helium) and becomes *thorium X*, which disintegrates into the *thorium emanation*, a gas the middle life of which is only 77 seconds, and which by the loss of an α particle changes into *thorium A*, which is succeeded by *thorium B*, *thorium C*, and *thorium D*; the final product is still unknown. As large quantities of thorium are treated in the manufacture of incandescent gas mantles, considerable quantities of meso-thorium and radio-thorium have been extracted; the elements mentioned in the preceding list. These radio-active preparations are used chiefly medicinally.

Professor Soddy has found that meso-thorium and radium have the same chemical properties. Moreover, according to his researches, thorium, ionium and radio-thorium form a first group of radio-active elements; another group includes meso-thorium, radium and thorium X. The chemical properties of the members of each group are the same, although the atomic weight of each element differs from that of the next by two units. On the other hand, meso-thorium, which is at the head of the second group, and radio-thorium, the last of the first group, have different chemical properties, although they have the same atomic weight. From these curious considerations, which chiefly concern the lineage of radio-active thorium, the ideas of Sir W. Ramsay as to radium may be approached. *Radium*, with an atomic weight of 226.5, disintegrates into an ephemeral radio-active gas, the *radium emanation*, which Ramsay has proposed to name *niton* (atomic weight 222.5); in its turn, passing through a series of phases, some long and others very short, this emanation transforms itself into *helium* (atomic weight 4). On comparing the atomic weight of these three elements, it is seen that the atomic weight of radium is equal to the sum of the atomic weights of the two others. This has led Ramsay to consider that radium is formed by the culmination of niton and helium. This would be helium nitonide, which constantly undergoes partial destruction, disengaging considerable energy.

Hot Bearing Avoided by the Use of Sheet Lead. ANON. (*Amer. Mach.*, xxxv, 167.)—One of the journals of a heavy locomotive gave continual trouble by running hot. The assumption was that this was caused by an overhard brass bearing in the box. The box was raised about ¼ inch off the journal, and a

piece of thin sheet lead was inserted between the shaft and the bearing surface of the brass bearing. The lead was thus worked into the pores of the brass, and the heating of the bearing ceased.

Distillation of Tin in Vacuo. E. TIEDE and F. FISCHER. (*Ber.*, xliv, 1711.)—Although tin melts at 230° C. it has a very high boiling point and is difficult to distil. This can be effected by heating several grammes electrically in a small magnesia or porcelain tube. The heating coil of platinum wire is wrapped around the tube and the whole system placed in an exhausted glass vessel, the outer walls of which are well cooled by flowing water. The first product of distillation is a yellow deposit, which gradually darkens and becomes almost black. The yellow powder, which is found with all varieties of tin, appears to possess all the properties of stannous sulphide. If the tin be prepared under special conditions so as to be quite free from sulphur, only a black distillate of pure tin is obtained, but in the air of the laboratory, this soon becomes contaminated with sulphide.

Behavior of Solid and Liquid Copper towards Gases. A. SIEVERTS and W. KRUMBHAAR. (*Zeit. Phys. Chem.*, lxxiv, 3, 277.)—In investigating this question the following conclusions were reached: (1) Oxygen is dissolved by molten copper in the cuprous state, and is not given off on solidification even in an oxygen-free atmosphere. (2) Nitrogen, carbon monoxide and carbon dioxide are not absorbed either by solid or liquid copper. (3) Solid copper absorbs hydrogen. (4) Solid copper does not absorb sulphur dioxide, but the molten metal absorbs a considerable quantity.

Sofia International Exhibition, 1912.—An exhibition of Industry, Commerce, Agriculture, Art, Education, Hygiene, Food, and Sports will be held at Sofia, Bulgaria, during the summer of 1912.

It will open early in June and continue until August or September. The movement is under the patronage of the Government of Sofia, and has the coöperation of the Chamber of Commerce and Industry.

The Royal Minister of Commerce and Agriculture of Bulgaria is honorary president of the Exhibition Association.

Further details can be had by addressing the Organization Committee of the International-Exhibition, 1912, Sofia, Bulgaria.

Influence of Copper on the Acid Corrosion Test. W. H. WALKER. (*Met. and Chem. Eng.*, ix, 453.)—The rate at which iron or steel is attacked by acid is no criterion of its purity, since the commercial metal frequently contains small quantities of copper which Breuil has shown (*J. Iron and Steel Inst.*, 1907) greatly

reduces its tendency to dissolve. On examining a number of specially-prepared samples, to some of which about 0.2 per cent. of copper was added during manufacture, the test pieces were exposed to the action of 20 per cent. sulphuric acid for three hours. The loss on each of the specimens free from copper was about 0.22 gramme, that on those containing copper varied from 0.0095 to 0.0075 gramme.

Blast Furnace Smelting with Oil. E. JACOBS. (*Eng. and Min. Jour.*, xcii, 434.)—Quoting from T. Kiddie's report, the author gives the results of a trial smelting of copper ore in a blast furnace using oil as fuel. The ore was obtained from the Boundary District of British Columbia, and the flux was composed of iron ore mixed with the slag from a previous operation. The rate of smelting was 110 tons per 24 hours, and the average consumption of oil was 14.6 gallons per ton of material smelted. The cost for oil was 43.8 cents per ton of ore.

British Regulations for the Sale of Acids. ANON. (*London Gazette*, Sept. 29, 1911.)—The new regulations for the retail sale of mineral acids are now in force. Sulphuric acid, nitric acid, and hydrochloric acid must only be sold retail in bottles distinguishable by touch from ordinary bottles and labelled with the name and address of the seller and with the words, "Poisonous" and "Not to be taken." These regulations have been made by the Privy Council in order to prevent accidents through the misuse of these acids. During 1909, 99 deaths were caused by hydrochloric acid, 7 by nitric, and 7 by sulphuric acid. Besides these fatalities, numerous accidents are frequently occurring, due to acids being contained in an ordinary bottle improperly labelled. Any person selling these acids without observing the new requirements will be liable to a fine of £5 ($25). In four months' time ammonia will be subject to the same regulations.

(It would be well for the United States to take the hint.)

Aluminum Nitride, Alumina, and Nitric Acid. G. L. BOURGEREL. (*Monit Scient.*, 1911, 561.)—By heating a mixture of bauxite and carbon in an electric furnace in a stream of nitrogen, an aluminum nitride, containing about 24 per cent. of nitrogen, is obtained, which on treatment with sodium hydroxide solution yields ammonia and sodium aluminate. The ammonia can be oxidized to nitric acid, and from the sodium aluminate, aluminum oxide can be obtained for the production of aluminum. However, if this process were used as a source of nitric acid or nitrates, there would be an enormous and unremunerative overproduction of aluminum. If the aluminum compounds simultaneously produced are disregarded, the cost of production of nitric acid or nitrates would be

greater than the present price of sodium nitrate, or than the price at which it can be produced by direct electro-thermic synthesis. By the direct process 166 kilos of nitrogen can be fixed, or 744 kilos of nitric acid produced, per kilowatt-year, and at an estimated cost of 70 fr. ($14) per horse-power-year in France. There is a prospect of the industry developing so as to compete with the nitride process, and supply the whole need of the country.

De-oxidation of Steel by Molten Ferromanganese. J. BRONN and W. SCHEMMANN. (*Stahl und Eisen*, xxxi, 1375.)—The use of molten ferromanganese results in a considerable saving of manganese, but this advantage is neutralized by the loss of manganese by volatilization when ferromanganese is melted in cupola, reverberatory, or ordinary arc electric furnaces. With a special furnace constructed to permit the use of arcs of low potential difference between the electrode and metal bath, ferromanganese can be heated considerably above its melting point without loss of manganese. Satisfactory results have been obtained with a small Röchling-Rodenhauser induction furnace. The molten ferromanganese is added to the steel as it is poured from the converter into the casting ladle, and is distributed so uniformly that there is no difference in manganese content between the first and last castings from a charge of 23 tons. Only about 35 per cent. of the usual amount of manganese is required.

Gases Contained in Steels. G. CHARPY and S. BONNEROT. (*Compt. Rend.*, clii, 1247.)—In the course of researches on cementation, a series of experiments were made on the gases liberated when steels are heated to 950° C. in vacuo. Under these conditions the velocity of liberation diminishes rapidly during the first few hours, but afterwards reaches a limit, indicating that part of the gas is liberated by a progressive reaction, and that it is not all dissolved or occluded. The initial velocity of evolution is greater with small chips and decreases with increase of pressure, but the ultimate total volumes liberated from equal weights of steel are the same. The volume of gas evolved from 1 gramme of steel varies from 0.31 to 1.06, according to the kind of steel. Although the gases contained 26 to 32 per cent. carbon monoxide, the quantity evolved appears to be quite independent of the carbon content of the steel.

A New Form of Metallic Filament Lamp. BOURRELLY. (*Soc. Belge Elect. Bull.*, xxviii, 165.)—After a summary of the chief qualities of tantalum and tungsten lamps, it is pointed out that the shape of the filament in the latter causes most of the light to be emitted sideways and very little downwards. Some new forms of the "Leila" type of lamp are described, with new meth-

ods of mounting the filament. In one the filament is arranged horizontally, in another there is a combination of vertical and horizontal filaments, and in a third a group of filaments converging downwards to a point is utilized, and the distribution of light is improved.

Soda Beds in British East Africa. ANON. (*Revue Sci.*, xlix, 11, 345.)—The great soda beds of the famous "Soda Lake" at Magadi, in East Africa, estimated to contain 200,000,000 tons, will shortly be worked by an English company with a capital of $5,000,000. The Government has agreed to continue the railroad from Uganda to the lake. The lake has an area of about 20 square miles. During the very short rainy season it is covered by a few inches of water, which will not materially interfere with the work. These beds consist of several well-defined, horizontal layers; the upper one is about 10 inches deep. As soon as a block of soda is extracted another crust forms in its place, and the natives claim this reproduction is effected so quickly that they can obtain soda from a given point for quite a number of years. There is reason to believe that these beds extend to the full depth of the valley in which the lake lies. One bore-hole, 9 feet deep, passed through a solid mass of crystallized soda. An average depth of 9 feet over the whole bed is the basis for the estimate of 200,000,000 tons.

Scientific Fisheries Service in France. ANON. (*Revue Sci.*, xlix, 11, 346.)—Five naturalists are engaged on this service. The deputy, M. F. Coreil, has proposed a law to make this official and to organize a scientific fisheries service under the Ministry of Marine. This proposition has been referred to the Commission of Marine Affairs.

The Action of Air Upon Coal. M. LÉCRIVAIN. (*Elect. Rev.*, lxviii, 910.)—All coals suffer characteristic oxidation in air, the ultimate result being spontaneous combustion if this oxidation continues for a sufficient time. The process of slow change which occurs at first can be divided into the following well-marked stages: (*a*) The physical state of the coal is altered. Surface oxidation causes minute fissures, which rapidly extend right through the lumps; thus the size of the sound pieces continually decreases. (*b*) A change of weight occurs in three stages: (1) loss by escape of moisture and occluded methane; (2) gain by surface oxidation; (3) loss by escape of hydrocarbons formed by the partial decomposition of the coal. Stages 1 and 2 occupy more or less time, according to the exact state and nature of the coal, but spontaneous combustion rapidly follows on stage 3. (*c*) A loss of calorific power and a deterioration of lighting and cooking values follow the escape of gases from the coal. If the carbon content of the

coal be low, and the atmospheric temperature high, this loss of gas is very rapid and may easily exceed 30 per cent. in one month's exposure. (*d*) The available by-products are diminished and the quality of the coke deteriorates. The quantity of ammonium salts recoverable may decrease 50 per cent. during three or four months. Coal stacked in the open air is bound to deteriorate, but the fire risk may be decreased by building only low banks. Storage under water is the best and safest procedure.

The Manufacture of Small Incandescent Lamps. ANON. (*Electrical World,* lvii, 1240.)—There are unusual difficulties in making lamps for switchboard service, as the carbon filament used has a diameter of 0.002 inch, about equal to that of a human hair. The Western Electric Company has made special lamps of this kind for telephone switchboard use. Intermittent lighting up and extinguishing does not affect them prejudicially, and some have been in use for over 50,000 hours' service and have undergone over a million flashes. The standard lamp for this work consumes 0.1 ampère at 24 volts; the bulbs are 1¾ inches long and 5/16 inch diameter. The resistance is about 250 ohms. Metallic filaments are unsuitable on account of their low resistance. The method of squirting and mounting such filaments is described in detail. Mercury pumps, though generally discarded for exhausting large-bulb lamps, are still used sometimes for miniature lamps.

Chromatic Aberration and Visual Acuity. L. BELL. (*Electrical World,* lvii, 1163.)—The eye cannot readily focus light of various wave lengths simultaneously; hence it is suggested that the most perfect definition will be secured by using monochromatic light; for this purpose the mercury vapor lamp and flame arcs, which are approximately monochromatic, are good. Experiments with an acuity photometer support the view that monochromatic light possesses a power of revealing detail greater than its photometrically measured brightness would indicate.

A New Indicator for Titrations. R. MELLET. (*Mon. Scient.,* lxxv, 837, 576.)—This new indicator is 6-sulpho, β naphtol-azo, m-oxybenzoic acid, prepared from the sodium salt. The sodium salt is purchasable as a black powder, with a violet tinge, very soluble in water, forming a blue-violet solution. For use, a 1 per cent. solution of the sodium salt is treated with decinormal hydrochloric acid, drop by drop, until it acquires a red color. Alkalies change it to violet-blue when neutral, or cherry-red when alkaline. The neutral tint is violet-blue, the alkaline cherry-red, and the acid bright red. The liquids to be titrated must be strongly colored by the indicator, contrary to the practice with the known indicators; *e.g.,* litmus, methyl-orange, etc. An acid solution is titrated with alkali until a deep violet-blue color is reached; an alkaline solution

is titrated with acid until the violet-blue tone becomes intensely bright red. It is of little use as a paper, for while the neutral (blue-violet) paper is very sensitive to acids, the acid paper (red) is only sensitive to very dilute alkalies, as with strong alkalies it passes directly from bright red to cherry-red, and the toning is not well marked. The advantages of the new indicator are: First, its intense coloring power, which makes the change of color clearly perceptible; second, a very clear change, whatever the volume of the titrated liquid; third, extreme sensitiveness, even for deci- or centi-normal solutions; fourth, sensitiveness in both senses, so that an acid solution can be titrated with a basic liquid, or a basic solution with an acid liquid, with equal precision.

The Action of Sirupy Phosphoric Acid on Alloys. MAX WUNDER and B. JEANNERET. (*Mon. Scient.*, lxxv, 837, 629.)—Certain metals or alloys obtained in the electric furnace, which sometimes resist the most energetic chemical action, are attacked and completely dissolved when powdered and heated with an excess of phosphoric acid above 1.75 in density. This applies to metallic silicon, zirconium, and tungsten, ferro-titanium, vanadium, silico-manganese, titanium nitride the alloy of ferro-silicon with 23 per cent. aluminum, boron-nickel, and carborundum. In all these reactions the carbon contained in the alloys remains, wholly or partially, in a flocculent condition in the sirupy liquid. The addition of water to these different sirupy liquids does not cause it to precipitate, but entirely dissolves it. On the other hand, the white precipitate obtained from certain alloys of silicium remains insoluble, both in water and in hydrochloric acid.

Mercury Mines of Mexico. ANON. (*Moniteur Scient.*, lxxv, 837, *Mercure* 69.)—In the province of San Luis Potosi there are 41 mines; the greatest quantity of mercury comes from the vicinity of Montezuma, 40 miles north of San Luis Potosi, and the neighborhood of Guadalcazar, 52 miles northeast of that town. It is extracted from metacinnabarite, a black mineral containing 60 per cent. mercury. The mines are open cuts at a height of 200 metres above sea-level, and belong to Mexicans. The yield is about 1,200 flasks of 75 pounds each annually. The mines of Guadalcazar are very old and were known to the Indians before the discovery of Mexico. The Trinidad mine yields 500 to 700 flasks. The minerals are cinnabar and black metacinnabar, and two others, fieroso and acerado.

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